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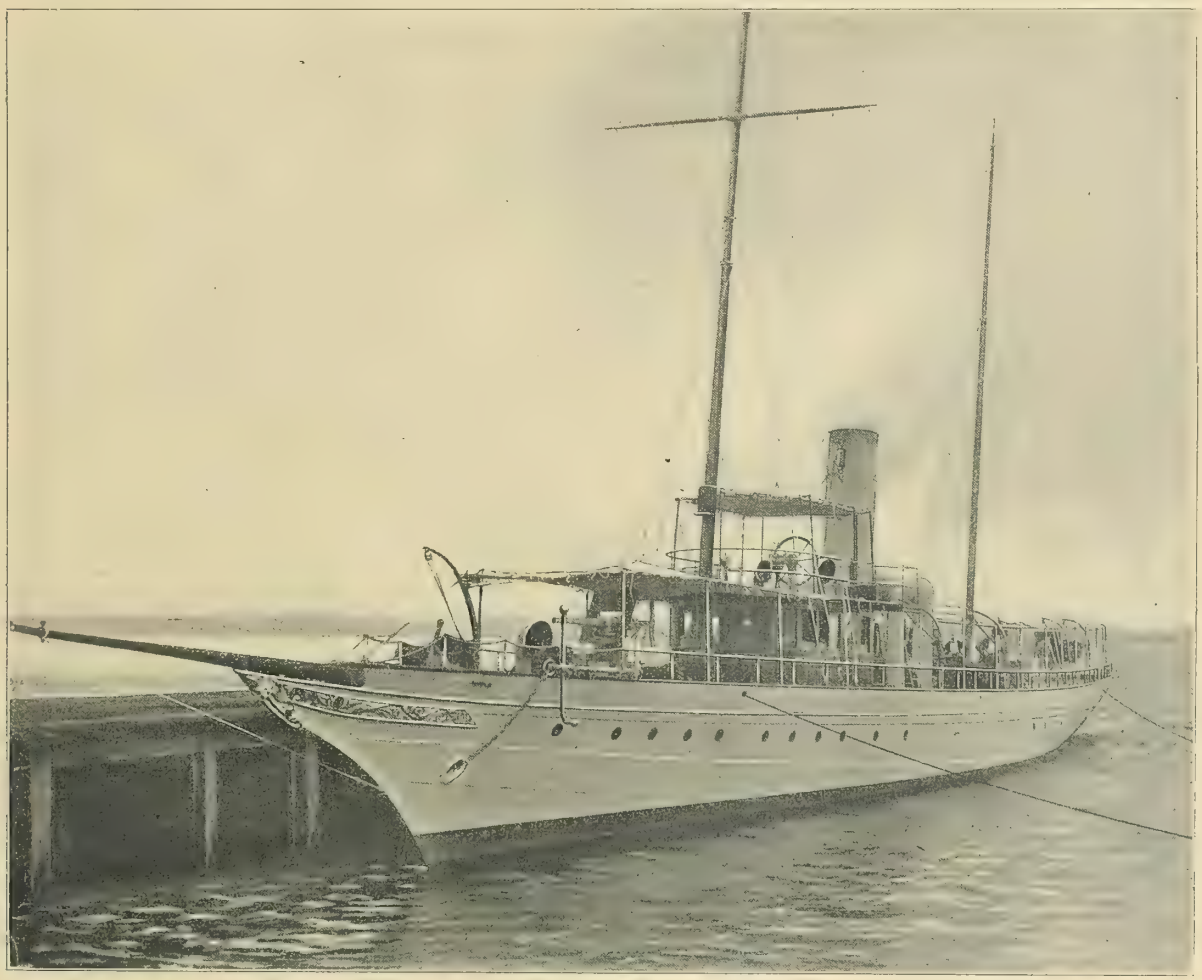
U. S. S. SYLPH, SELECTED BY THE NAVY DEPARTMENT AS THE PRESIDENT'S YACHT.

Our frontispiece shows the steel steam yacht Sylph which has been selected by the Navy Department as the official or President's yacht. She was designed by Gardner & Cox, of New York, and built by the Delaware River Iron Ship Building and Engine Works at Chester, Pa., this year. Her dimensions are: Extreme length, 152 ft.; beam, 20 ft.; depth, 10 ft. 6 in.; draught, 8 ft. 9 in.

This yacht was in an unfinished condition on the stocks at the time the Naval Board on auxiliary vessels was purchasing boats during the recent war. She was known as No. 295. The Board inspected the yacht and decided to purchase her on condition that a speed of 15 knots would be guaranteed. This was agreed to by the designers and builders, though she was designed for 14 knots only, and from private ownership the yacht was transferred to the Government. The change of use from a pleasure yacht to an auxiliary gunboat necessitated a number of



U.S.S. SYLPH, 159 TONS, THE PRESIDENT'S YACHT, LATELY AN AUXILIARY GUNBOAT.

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structural changes in the vessel, converting passenger accommodation into crew space and putting in magazines, etc. When the speed trials came off the guarantee given by the owners was more than realized, as the average for six hours over a course in the Delaware river was 16 knots, with 600 indicated horse power and a rate of coal consumption of but 1.6 lbs.

The Sylph is a single-screw boat with main engine of the vertical triple-expansion type. It is arranged with the H. P. cylinder forward, I. P. cylinder aft, and L. P. cylinder in the middle, the cranks being 120 deg. apart and following in this order: H. P., I. P. and L. P.—the cranks turning to starboard from the top center. The cylinders are lagged on the top and sides with asbestos and cased with Russia iron. The H. P. and I. P. cylinders have each one and the L. P. cylinder two piston valves. The valve gear is of the Stephenson link motion, with double-bar links. The engine was designed to develop 550 H. P. when running at 320 revolutions, with steam pressure of 225 lbs. per sq. in. in the boilers. The cylinders are supported by wrought steel columns, diagonally braced and resting on the bed plate. The guides for the crosshead slippers are of cast iron and are secured to the cylinders on top and to a longitudinal guide bar and the columns on the bottom. The crank shaft is hollow and in one section, of wrought steel. Air, circulating and feed pumps are all independent. The steam reversing cylinder is attached to the bed plate.

Some of the machinery dimensions are:

Cylinders, number	3
Cylinder, dia. H. P.	10 in.
Cylinder, dia. I. P.	16 in.
Cylinder, dia. L. P.	25 in.
Ratio net areas of pistons H. P. to L. P.	7.71
Ratio net areas of pistons H. P. to I. P.	3.16
Ratio net areas of pistons I. P. to L. P.	2.44
Stroke	16 in.
Valve, dia. H. P.	6 1-2 in.
Valve, dia. I. P.	10 1-2 in.
Valve, dia. L. P. (two)	10 in.
Piston rods, dia.	2 in.
Connecting rods, length center to center	38 in.
Crank shaft, length	8 ft. 5 in.
Crank shaft, dia.	5 in.
Crank pins, length	8 in.
Dia. axial hole	3 in.
Propeller shaft, length	35 ft. 3 in.
Thrust shaft, length	9 ft. 8 in.
Thrust shaft, dia.	5 in.
Thrust collars, number	6
Thrust collars, thickness	1 1-8 in.
Thrust collars, dia.	10 in.
Area of thrust surface	353 sq. in.

The circulating water is supplied by one centrifugal pump with runner 20 in. dia., and suction and discharge pipes 6 1-2 in. dia. There is one Davidson vertical, duplex air pump, with water cylinders 8 in. dia., steam cylinders 6 in. dia. and a stroke of 8 in.

There is one main feed pump and one auxiliary feed and bilge pump, both of the Worthington Admiralty pattern, with water cylinders 3 in. dia., steam cylinders 4 1-2 in. dia. and stroke 4 in.

Forced draft is supplied by a 42 in. fan, drawing air from the boiler room and delivering it into an air duct leading to the ash pits. The fan is driven by a single-cylinder engine, 6 in. by 3 in.

The electric outfit consists of a General Electric, direct-connected dynamo and engine, of 100 16-candle power light capacity, located in the engine room. The dynamo, which is of the quadrupolar type, is driven by a double cylinder, vertical, engine connected directly to the armature shaft. The sizes of cylinders are 4 in. dia. and 4 in. stroke.

There are two Almy water-tube boilers, placed alongside of each other in a water-tight fire room. They are fitted with double fronts and closed ash pits for forced draft. The boilers are so connected that they can be used together or worked independently. The grate surface for each boiler is 22 1-2 sq. ft. and the heating surface 750 sq. ft., making a total for both boilers of 42 sq. ft. grate surface and 1,700 sq. ft. heating surface. The working pressure allowed is 250 lbs. per sq. in. The outside dimensions over both boilers are 9 ft. 8 in. by 6 ft. 7 in., and the total weight with water, including all fittings, is 24,500 pounds.

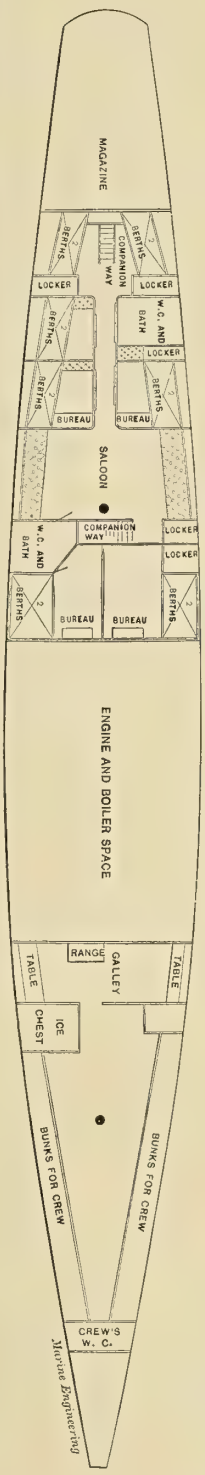
Particulars of the propeller, which is right-handed, three bladed and of steel, are here given:

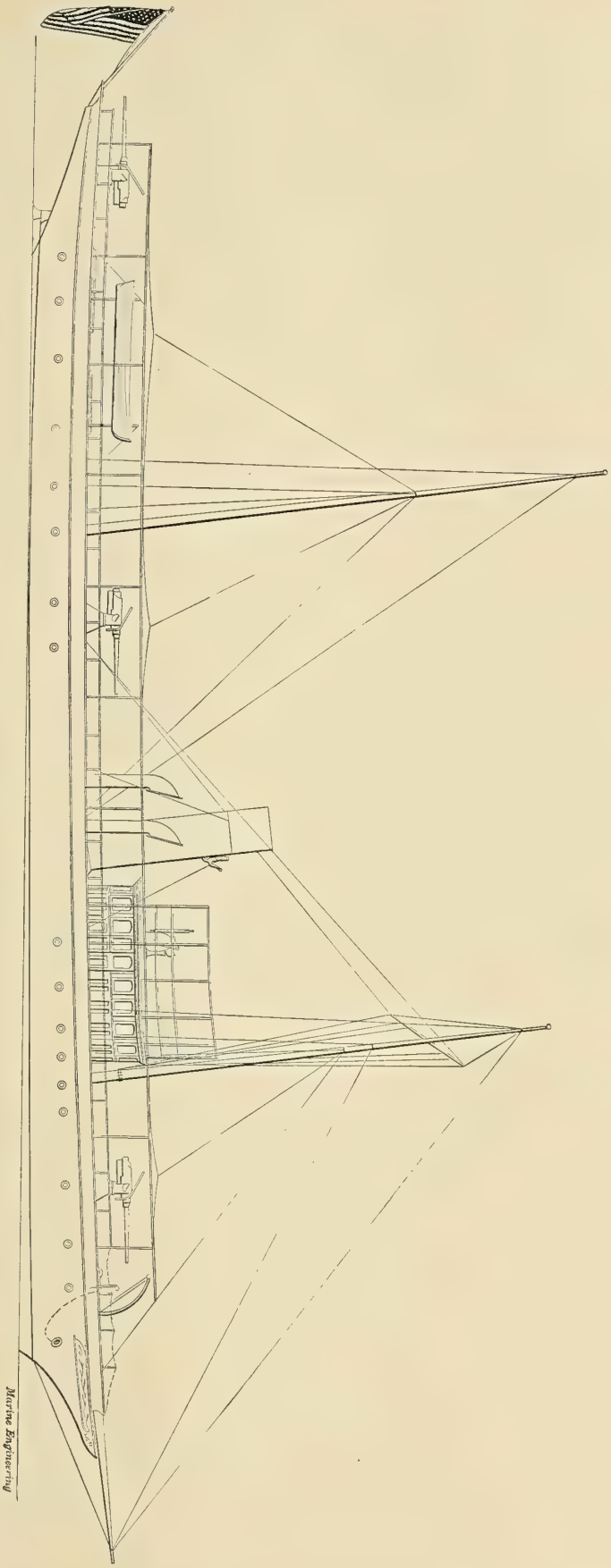
Blades, number	3
Blades, dia.	6 ft. 3 in.
Hub, dia.	18 in.
Blades at root, thickness	2 1-2 in.
Helicoidal area	13.25 sq. ft.
Disc area	30.67 sq. ft.
Pitch	7 ft. 6 in.
Top of propeller, immersed	10 in.

Cast iron is used for the condenser shell which is cylindrical and fitted with bronze tube plates and ends. It is placed on the port side of the engine room and secured to the floors and frames of the hull. The circulating water passes through the tubes. The particulars are:

Tubes, number	663
Tubes, dia.	5-8 in.
Length between tube sheets	6 ft.
Cooling surface	650 sq. ft.
Ratio of cooling surface to H. S.	1:2.3

U. S. S. Sylph, as equipped for blockade duty, mounted a 6-pdr. bow chaser, two 3-pdr. broadside guns, and a 6-pdr. stern chaser. Her ammunition rooms were below the water line forward and aft, and protected further by water tanks. The official trial was made on the Delaware river off Deep Water Point in seven fathoms of water, and at top speed the wave and consequent change of trim due to bottom retardations was quite noticeable. The task was a difficult one, for both hull and machinery had been designed for a speed of 14 knots and now had to show over 15 knots for four hours. This





PROFILE AND ACCOMMODATION PLAN OF THE U. S. S. SYLPH—THE PRESIDENT'S YACHT—BUILT AT THE ROACH YARD, CHESTER, PA.

involved the burning of 40 lbs. of coal per sq. ft. of grate surface, and the increase of revolutions meant the development of 650 H. P. and a piston speed of 900 ft.; also putting heavy duty on all the auxiliaries. Everything worked out satisfactorily, however, and for five hours the boat was run at full speed, with an average mean, with and against tide, of 16.2 knots.

The Sylph as originally laid out was similar to the steam yacht Malay, designed by Gardner & Cox, and also built at Roach's yard this year for Dr. Charles G. Weld, of Boston, her dimensions, machinery, equipment, etc., being practically the same. When the examining board reported favorably on the boat she was plated and her deck laid and machinery put in place. To suit the altered conditions instead of a long central deck house, as on the S. Y. Malay, a forward house of mahogany was provided to be used as a dining saloon. This connects with the galley below. The officers' rooms forward were taken out and thrown into the forecastle to take care of the larger crew required. Below aft there are, as in the S. Y. Malay, four large state rooms, one of them the full width of the ship, all finished in white and gold, a large main saloon, and a double state room at the extreme after end; also two bath rooms with lavatories.

The Sylph is lighted throughout with electricity and provided with all the modern appliances suitable for a yacht of her type. Her coal capacity is 50 tons, and while primarily built as a cruiser her moderate draught would enable her to enter almost any of our ports. She will probably be largely used in carrying the President and his guests on short trips on the Potomac in the warm season. Her light draught makes her specially adapted to this use, and the fact that her deck house is limited in size will not interfere with the pleasure of those on board, her large space of open deck making a fine promenade.

The battleship Illinois will be launched from the yard of the Newport News Shipbuilding and Dry Dock Co. early this month. This vessel, which was authorized by the Act June 10, 1896, was laid down in February, 1897, and is under contract to be completed next September. She will be of about 11,500 tons displacement, and of the same general dimensions as the Kearsarge and Kentucky, launched from the same yard early this year. Her twin-screws will be driven by triple-expansion engines of 10,000 horse power, and a trial speed of 16 knots is expected. The batteries of this ship will differ very materially from those of the ships of the Indiana class. There will be four 13-in. rifles, mounted in two turrets, and fourteen 6-in. rapid-fire guns at the sides. There will also be extensive secondary and machine gun batteries and four long Whitehead torpedo tubes. The Harveyized armor protection ranges from 10 in. to 17 in. in thickness. The contract price for the Illinois is $2,595,000.

DISCUSSION OF THE MERITS OF TORPEDO CRAFT AND SOME OF THE FEATURES OF DESIGN AND CONSTRUCTION.—II.

BY WILLIAM A. FAIRBURN.

HINTS ON DESIGN IN GENERAL.

The machinery sometimes determines the depth of a boat, but the depth need not be sufficient to completely envelop the machinery, for there is no objection to a boiler casing or even an engine casing above deck. If the depth is small the scantlings of the vessel (or the material which contributes to the strength of the ship in fore and aft bending) will have to be heavier to obtain the same strength, but with a small depth, if one does not go to a ridiculous extreme, there is usually a net gain in weight of hull. The smaller the depth the more stability the boat will possess, for providing the center of gravity of the machinery is fixed, the center of gravity of the hull varies directly as the depth and the center of gravity of the armament and deck equipment, etc., is lowered, just as much as the depth is reduced. The coal capacity, if the depth is decreased, would be reduced somewhat, which is a bad feature; but its center of gravity would be lowered, the result being an increase of stability. Again, a deep boat necessitates large freeboard, and whilst this may contribute somewhat to sea-going qualities it has many great disadvantages, such as increase of target, the vessel being much more easily discernible at sea. When a torpedo-boat is designed for extreme speed, such as 30 or 31 knots on a displacement of 125 to 150 tons, it is essential that the depth be kept as small as possible, and a hog sheer used so as to reduce the weight of hull at the ends of the vessel. A hog-sheered boat, even when quite low forward, has proved in actual service to be an admirable sea boat, and she possesses great natural strength, with a neat, speedy, powerful appearance, provided the smokestacks and signal staff are worked plumb and not raked. The following table of depths for torpedo-boats will give, as a rule, good proportions for high speed, but the depth may vary in a design quite a little from these figures owing to peculiar requirements and conditions:

Displacement.	Depth.
150	10.6 ft.
200	11.0 "
250	12.0 "
300	13.0 "
400	14.0 "

The draught of the hull proper of torpedo-boat varies from about 3 ft. for a second-class coast defence boat to about 7 ft. for the largest destroyer. A suitable draught for a 150-ton torpedo-boat is about 4 ft. 6 in.; for a 250-ton destroyer, 5 ft. 6 in., and for a 350-ton destroyer, 6 ft. 6 in. There is a tendency in this country to make the model of torpedo-boats very fine, and some boats have been built with a block co-efficiency of much less than .4. Owing to the large ratio of length to beam such a "toothpick model"

is not essential for high speed, and a co-efficient of fineness of nearly .5 would give about as good a result as the finer form on a speed test in smooth water, and a very much better performance at sea.

The length of a torpedo-boat should be fixed by the length required by the machinery, plus the shortest length in which the complement can be berthed. After the preliminary figures are made and the power required to drive the proposed boat is decided upon, the machinery should be drawn in on the plan, making as compact an arrangement as possible. Berthing space for the crew must next be added on forward—some may be given berths and others hammocks so as to make this length as short as possible—and the accommodation for the officers and machinists is generally located aft, in such a fore and aft length that the center of gravity of the vessel will be in a suitable position in relation to the center of buoyancy.

It is impossible to design a torpedo-boat that will trim on an even keel in all conditions, but yet it is desirable to make the change of trim as small as possible and make the various water lines under the different conditions suitable for speed. The "Camel" arrangement of machinery, although it means a little added weight, due to increased length of shafting, etc., has many advantages. By this arrangement the engines are located in the center of the vessel, with a boiler room forward and another aft. If twin screws, the engines may be abreast of each other in a common compartment with the condensers aft of the main engine; but a separate watertight compartment for each engine, although it necessitates a greater length of machinery space, is considered preferable to-day. By this arrangement a coal bunker can be worked on one side of each engine room with direct communication to one of the fire rooms, provided that two boilers only are used, and these located at the extreme ends of the boiler compartments, the fire rooms adjoining the engine rooms. One great advantage of the "Camel" arrangement of machinery is its effect on change of trim for the various conditions from extreme light to extreme load. The writer knows of two torpedo-boats with exactly similar machinery, arranged in the usual manner in one vessel and "Camel" fashion in the other. Whereas the change of trim is 27 in. in the former it is only 9 in. in the latter.

There are only single and twin-screw torpedo vessels afloat to-day, but as the size of these vessels is constantly increasing, it will soon become essential to either build triple-screw destroyers or twin-screw vessels with four engines, i. e., two engines on each shaft. The latter arrangement has been used on the U. S. armored cruisers Brooklyn and New York, and it has many advantages. The length of the machinery spaces in torpedo-boats varies from about 40 to 50 per cent of the total length. For a first-class torpedo-boat 45 per cent of the vessel's length is a suitable length for the machinery, and for a destroyer about 50 per cent, although the writer is of the opinion that even these percentages could be increased with advantage by taking from the living spaces. By doing this, the weight of hull would be decreased, the boat made smaller, the cost greatly decreased, and the speed increased.

FRENCH TYPE OF TORPEDO-BOAT DESTROYER—ONE OF THE NEWEST AND FASTEST VESSELS.
(Reproduced from the Navy and Army Illustrated, London.)

NECESSARY COMPLEMENT

The complement or number of men required to man a sea-going torpedo-boat or destroyer varies from about one man for every five tons displacement to about one man for every six tons displacement. A torpedo-boat complement is not sufficient to run the vessel for any length of time at full speed with changing watches, but all the men on board are required to be at their stations when the order is given to steam at maximum power. Therefore a torpedo-boat could not keep up her maximum speed for any great length of time, for the complement would be physically unable to stand such a great stress.

When estimating the complement necessary to man a torpedo-boat, it is desirable that there should be one man for every engine cylinder and one extra man for each engine room; two men for each furnace, and one extra man for each fire-room. The number of officers and the crew for working the guns and navigating the vessel is quite a variable quantity, for each Navy seems to have different ideas as to what is a sufficient number.

MATERIALS OF CONSTRUCTION.

The scantlings of a torpedo-boat must be made as light as possible, for the higher the speed the lighter must be the weight of the hull. Considerable science must be displayed if one is to correctly proportion the scantlings of a high-speed torpedo-boat. A merchant vessel of about 100 tons, built according to Lloyds' highest class, will have a stress of about only 1.5 tons when on a wave of her own length. An Atlantic liner, built according to the same requirements, will have a maximum stress of about 10 tons. These figures may not represent the actual stresses that come on the upper works per sq. in., but such figures are used as a standard means of comparison. In merchant work the same thickness of material must be allowed for corrosion, etc., on a small vessel as on a larger one. If an Atlantic liner has shell plates 1 in. thick, and of this 7-8 in. is necessary for strength and 1-8 in. for corrosion, the amount of metal fitted for the latter purpose is .125 of the total metal. But on a 100-ton boat if 1-16 in. is all that is necessary for strength, and to the same 1-8 in. is added for corrosion, the metal fitted for the latter purpose is .66 of the total steel that contributes to fore and aft strength. This explains why the scantlings of a small vessel are so much heavier than those of a large vessel in proportion to their size. In the design of torpedo-boats a margin cannot be added to the plating to allow for such matters as corrosion, grounding, banging against wharves, etc., for the scantlings must necessarily be made extremely light. Such boats must be well cared for in actual service, and it is desirable that they should be galvanized and kept in good water. The stresses allowed on torpedo-boats do not run as high, however, as in large merchant vessels, and whereas the latter may have a stress of say 10 tons, torpedo-boats do not go more than about 6 tons per sq. in. The assumption made when figuring this stress is the same in each case, viz.: a vessel poised on a wave of her own length and with a height equal to 1-20 of her length; but here, it must be remembered, there is quite a difference, for whereas small boats are constantly meeting with waves of their own length, which strain them to their maximum, large ships seldom, and sometimes, it may be, never meet waves of their own great length. Therefore it is desirable not only to consider stress, but the frequency with which the vessel may be expected to meet this maximum stress, and this being the case, we must provide a large margin on the small ships. High-grade steel should be used in the construction of all torpedo-boats, as this affords by far the best way of reducing the weight of the hull. Suppose a stress of 6 tons is all right for a steel hull built of material with a tensile strength of 30 tons, the factor of safety allowed here is 5.—elastic limit should be usually considered when dealing with factors of safety. If now a boat is designed with steel of 40 tons tensile strength one can allow, with the same factor of safety, for a stress of 8 tons, which will mean for the same strength a great reduction of weight. Nickel steel with a tensile strength of from 37 to 43 tons and with an elongation in 8 in. of from 17 to 13 per cent, is being used at the present time in Europe. It should be remembered that when high-grade steel of say 40 tons tensile strength is used in conjunction with ordinary steel of about 28 tons, there is no beneficial effect produced unless the high-grade steel is placed on each side of the neutral axis and as far from it as possible. If, as is now proposed in one of the new U. S. destroyer designs, 44-ton nickel steel is used on the deck and ordinary 28-ton steel at the keel and elsewhere, the lower part of the vessel will break in two when a certain stress is produced, and even if the top member of the girder does not break, what good can it do by remaining intact if the remainder of the vessel collapses? In torpedo-boats, as the heavy weight of the machinery and coal is concentrated amidships, the greatest stress will be in "sagging" or the keel in tension. The bending moment of such boats in the hollow of a wave—the worst condition—depends greatly on the space occupied by and the weight of the machinery, but it is usually about 1-20th of the product of the displacement and length in foot tons. Galvanizing by the usual hot process makes the material for torpedo-boats very unsatisfactory and hard to work, but galvanizing by the cold electric process gives excellent results and a much thinner layer of zinc.

DISPOSITION OF WEIGHTS.

When proportioning the scantlings of a torpedo-boat very great care should be given to the location of the neutral axis, for it is quite possible to add weight and yet make a weaker vessel. The scantlings of the boat should be greatly reduced at the ends of the vessel, and by just how much should be carefully figured out, for many excellent torpedo-boats to-day have the great fault of having their ends much too heavy. Much might be written on the methods of decreasing weights in the construction of torpedo-boats. Every pound of metal affects the final results. Flanging, for example, should be made to take the place of angle bar connections. Angle bulbs are greatly superior to angle bars even when fitted with reverse bars. The heavier the shell plates the further apart the frames should be located, and many builders to-day are greatly

GERMAN TORPEDO BOATS IN FLEET MANŒUVERS.
By courtesy of Corvetten-Capitain Hermann Gercke, Imperial German Navy.

BRITISH TORPEDO-BOAT DESTROYER BRUISER.
By courtesy of John Platt, M.E.

increasing the weight of the hull by spacing the frames much closer than is really necessary. The frames should be located so as to make the shell keep its shape, and the deck beams so close that the plates will not buckle between beams when the usual load is applied. Heavy scantlings will never reduce vibration, but it is essential that the hull be made rigid, and M. Normand has an admirable scheme of connecting the engine to the deck and engine foundation so that the vibratory forces are conveyed to the shell and deck plating. The usual method of estimating the weight of the hull of a torpedo-boat is to take a certain percentage of the displacement, but this is a very unsatisfactory way, as it takes no account of depth, fulness, or trial load carried. The most satisfactory way is to work out a co-efficient of the product of the principal dimensions, viz.: length, beam and depth for various known boats, and this co-efficient for similarly constructed vessels will be practically a constant.

Approx. weight of hull of a torpedo boat=.002 L. B. D.

Published weights or data should be multiplied by a "Human Co-efficient," and even if correct it is very difficult to determine just what is the weight of hull and what comes under the head of equipment and trial load. Even scaled weights of a hull are often deceiving, for they seldom if ever agree with the displacement scale when the boat is launched.

CONCERNING THE MACHINERY.

Now let us briefly consider the machinery. If we are searching for the greatest simplicity and minimum weight and cost a 3-cylinder triple-expansion engine is preferable to a 4-cylinder triple or quadruple-expansion engine. The maximum piston speed which it is considered desirable to run at to-day is about 1,200 ft. per min. A little longer stroke than is usually used, with a decreased number of turns, and the same piston speed would give splendid results. A 21 in. stroke for a 2,000 H. P. engine and a 24 in. stroke for a 3,500 H. P. engine the writer considers would be preferable to the usual 18 in. stroke and 400 revolutions. The latter figure seems to have been a standard for the engines of a destroyer. An increased stroke means, besides numerous minor advantages, a reduction in the inertia forces and a more durable engine. The mean effective pressure referred to the low-pressure cylinder on modern torpedo-boats varies all the way from 40 to 60 lbs., and the ratios of cylinder from about 4 to 7; a good average being 50 lbs., with a cylinder ratio of about 5.

The condensers in almost all cases are of the scoop form, the circulating water being driven through the tubes by the speed of the ship. The balancing of a torpedo-boat engine is a delicate problem, but having in mind general efficiency and a reduction of weight, the best results seem to be obtained with counterweights on tne cranks, the cylinders placed as close together as possible with the valves on the sides, and a diagonal tie on the engine to take the fore and aft couple This scheme orignated with M. Normand, and, as before mentioned, he transfers these vibratory forces, by means of this tie and the fastening of the engine, to the fore and aft metal of the hull, the deck and the shell, and therefore vibrations of the hull are hardly perceptible. There are so many different types of first-class small tube boilers suitable for torpedo-boats that it is impossible to tell which is the best all 'round torpedo-boat boiler. The Yarrow, Thornycroft and Normand boilers probably lead, as these three have successfully stood the test of many years. From 20 to 40 I. H. P. has been obtained per sq. ft. of grate area, the average being about 25 I. H. P. With steam jackets on the cylinders, efficient feed heaters and first-class firing, this figure has been increased to as high as 45 I. H. P. per sq. ft. of grate surface.

The coal consumption of modern torpedo-boats is usually about 2.5 lbs. per I. H. P. per hour at full power, and this figure drops down to about 1.5 to 1.7 lbs. at the economical cruising speed, usually 12 to 14 knots. The French torpedo-boat Forban had on her official 14 knot coal consumption trial a consumption of less than 1 lb. per I. H. P. per hour, but it must be remembered that the French use briquettes for fuel, and this may account somewhat for her remarkable economy. In the design of a torpedo-boat care should be taken in locating the coal bunkers, for in quite a number of boats afloat to-day there is great difficulty in feeding coal to the firerooms. Tie rods in fore and aft bunkers should be avoided as much as possible, for it is, even under the most favorable conditions, an extremely difficult job trimming and feeding coal in a torpedo-boat's wing bunkers.

POINTS ON PROPELLERS.

It has been found by experiment that an effective thrust of 12 lbs. or an indicated thrust of 20 lbs. per sq. in. of the propeller's projected blade area is the maximum thrust that a screw will develop with efficiency. This fact will determine the blade area of a propeller suitable for a proposed torpedo-boat, as the usual practice is to allow for an effective thrust very close to this maximum or between 10 and 12 lbs. per sq. in. After the blade area has been determined, it is a comparatively easy matter to determine the diameter and pitch of the wheel. Great care should be taken in giving the propeller suitable immersion and ample clearance to the hull, and even the fact of keeping the draught of the boat under the screws a minimum should be considered, but secondary to ample immersion and clearance. A screw for a sea-going torpedo vessel should have about 24 in. immersion, and should never be nearer to the hull than 15 in. Although unfortunately, this has been done on some recent boats in this country with disastrous results.

MACHINERY WEIGHTS.

The total weight of the machinery of torpedo-boats varies from about 45 to 75 lbs. per I. H. P. The best result obtained in our country up to the present time is about 50 lbs. per I. H. P. Some European boats go as low as 36 lbs., and some British 27 knot destroyers have machinery as heavy as 78 lbs. per I. H. P.

SPEED AND POWER.

Too much faith should not be put in the ordinary published data for speed and power of torpedo vessels. The displacement is in almost every case decidedly misleading, even if the indicated horse power and speed are stated approximately correct. In about 75 per cent of the designs for modern American torpedo-boats the power estimated on is much too low. It is a surprising fact that the larger the torpedo-boat the more difficult it is to obtain high speed. If the curve of the Admiralty propulsive co-efficient based on displacement is carefully studied it will be noticed that the value of this co-efficient is a minimum at the rising speed before mentioned as $9\sqrt[6]{\text{Disp.}}$ At this speed the boats commence to rise out of the water, and as the displacement becomes less the value of the coefficient $\frac{D^{\frac{2}{3}} \times \sqrt{\ }}{\text{I. H. P}}$ becomes greater. This gradual increase of efficiency will continue as the speed increases, with no further points of maximum or minimum values on the curve. The rising speed of a 125-ton torpedo-boat is about 20 knots, and a French boat of this displacement has steamed at 31 knots, the efficiency of propulsion gradually increasing for the last 11 knots. At low speeds the value of the Admiralty co-efficient is quite low, owing to the large and powerful machinery working at a very low power. There is therefore one maximum and one minimum in the curve of Admiralty co-efficients for every torpedo-boat. It follows, therefore, that no torpedo-boat should be designed to have a maximum speed within 2 knots on either side of the rising speed, but it will be noticed that the greatly increased size of destroyers is gradually bringing the maximum speed of these vessels to the point of minimum efficiency.

It is interesting to notice how the power of a torpedo vessel varies in relation to speed. A 400-ton destroyer will require over 8 times as much power at 30 knots as she will at 15 knots. A large first-class torpedo-boat requires about 2 1-2 times as much power to attain a speed of 20 knots as she needs for 15 knots, 4 1-2 times as much power for 25 knots, and about 7 times as much power for 30 knots. If at 15 knots an increase of speed of 1 knot means about 150 more I. H. P., an increase of 1 knot in the boat's speed at 30 knots will require about 400 I. H. P. On such a first-class sea-going boat the power required for a speed of 30 knots is just double that required for 23 knots.

TRIAL DIFFICULTIES.

High speed, with light hulls, quick running, light machinery and express water tube boilers is not as easy to obtain as some builders seem to think. Great care should be taken to have the design all right in the first place. When the boats are built and ready for trial, even if the design is first class in every respect, the builder's troubles commence. The firemen must be trained to work like so many machines, and it requires great skill and a strong constitution to fire these boilers, with grates as long as 9 or 10 ft. and a consumption of about 70 lbs. of coal per sq. ft. of grate per hour. Great skill must be displayed by the engineer who has charge of this "tuning up," and the way the trials are conducted is almost responsible for one half of the difficulty there is in obtaining this high speed.

SCARCITY OF PROPER MATERIAL.

Our torpedo-boat builders are experiencing great difficulty in obtaining some of the material which they need in the construction of these speedy vessels. The same thicknesses of high grade rolled and cast steel cannot be obtained in this country that are furnished every day by various European steeel makers, for some domestic steel makers at present refuse to furnish such material as is readily supplied abroad. They could do it if they but went to the expense of adapting their plants to this class of work. One would naturally expect some of our more enterprising firms to do this, as the demand at present seems to be fairly great and large enough to warrant an outlay for an increase of plant.

QUESTIONS OF COST.

Unless a shipbuilding firm has had some experience in the construction of torpedo-boats it is a very difficult matter to estimate the cost of the same, and the difficulty increases as the speed increases. The present tendency of American firms is to bid ridiculously low, and some of the prices are much lower than figures for the same class of work abroad. When many of the bidders on this class of work have encountered the difficulty of building and running the trial of these especially fast boats, their figures on proposed work will doubtless be much higher than they are at present. For a large 30-knot destroyer about $900 per ton of trial displacement and $1,100 per ton weight of hull and machinery is a fair price, while a first-class 30-knot torpedo-boat is worth about $1,100 and $1,300 respectively.

A large railroad transfer boat for use on the Mississippi at New Orleans was launched recently from the yard of the Iowa Iron Works at Dubuque. This ferry is 300 ft. long; 56 ft. beam, and when completed she will have four tracks with capacity for thirty-two loaded cars. This company built the torpedo boat Ericsson.

CHIEF CHARACTERISTICS OF BATTLESHIPS AND MONITORS PROVIDED FOR IN NAVAL SHIPBUILDING PROGRAMME OF 1898-99.

All the new ships for the navy provided for in the naval programme of 1898-99, under the Act of May 4, 1898, will soon be under construction at various private yards throughout the country. The programme includes three first-class battleships, four coast-defense monitors, twelve torpedo boats, and sixteen torpedo-boat destroyers. Bids for the battleships, torpedo boats and destroyers are now under consideration by the Navy Department, and probably by the time this appears in print the awards will have been made.

In previous issues we have given the chief characteristics of the torpedo boats and destroyers and the bids in detail. Here we propose to outline the leading features of design of the battleships and monitors.

The experiences gained during the recent naval operations were very opportune, for practical use will be made of them in the construction and equipment of all the new vessels. A notable example of this is in the demand of the Navy Department for increased speed of the battleships, though this had been for a considerable time urged by the Engineer-in-Chief, George W. Melville.

As originally specified the battleships were to be of 11,500 tons displacement and 15 to 16 knots speed, with a steaming radius of not less than 5,432 knots at 10 knots speed. The requirements were subsequently changed to vessels not to exceed 388 ft. in length of 12,500 tons displacement and 18 knots speed, with bunker capacity for

TABLE SHOWING THE BATTLESHIPS ORIGINALLY CALLED FOR BY DEPARTMENT AND THOSE WHICH WILL BE OBTAINED.

Particulars.	Original design.	Contractors' offer.
Speed, knots	16	18
Displacement, tons	11,500	12,500
Horse power	10,000	16,000
Coal on trial, tons	800	1,000
Coal, total tons	1,200	2,000
Radius of action, knots	5,400	10,000
Cost	$2,600,000	$2,890,000

2,000 tons of coal and a steaming radius of 10,000 miles at 10 knots. An exceedingly satisfactory feature of the amended type of ship is that it comes within the appropriation made by Congress for the slower (15 knot) vessels. The battleships are officially known as 10, 11 and 12, and are to be named the "Ohio," "Maine" and "Missouri."

For an improved type of battleship the following bids were received:

Newport News Shipbuilding and Dry Dock Co., Newport News, Va., submitted builders' plans for one 12,500-ton, 18-knot battleship, to be completed in 32 months, for $2,850,000. The Naval Board made some objections to the battery of this proposed ship, but received an assurance from the company that this would be arranged in accordance with the requirements of the Board.

Union Iron Works, San Francisco, one 12,200-ton, 18-knot battleship, to be completed in 32 months, for $2,899,000. This ship to be built according to the Department plans, except as to the propelling machinery and the length, this being increased to 388 ft., to get the additional displacement.

William Cramp & Sons Ship and Engine Building Co., Philadelphia, put in alternative bids; one for a 12,150-ton, 18-knot battleship, 384 ft. long, on Department plans except as to machinery, to be completed in 32 months, for $2,885,000. The other bid was for a vessel of 12,500 tons, 18 1-4 knots speed, to carry 2,000 tons of coal and have a radius of action of 10,000 knots.

In the original department designs for the battleships the propelling engines were of the vertical triple-expansion, four cylinder type. The boilers were single-ended Scotch designed for a working pressure of 210 pounds. The increase of displacement and speed decided upon will necessitate a revision of the machinery plans to get the increased power. Possibly three-cylinder engines may be adopted, and it is very probable that water-tube boilers will be used. In one case the Niclausse type is favored.

In points of design and equipment, other than the propelling machinery, the battleships as now proposed will be essentially the same as those originally drawn by the Bureau of Construction and Repair, under the supervision of its Chief, Commodore, Philip Hichborn.

The hull is to be of steel, not sheathed, with double bottom and close watertight subdivision. Two military masts will be fitted, and the usual outfit of boats. There will be a side armor belt of a maximum thickness of not less than 16 1-2 in. and a mean depth of 7 ft. 6 in. The belt is to extend at least from the stem to the after barbette and will be of maximum thickness through the engine and boiler spaces, and from thence forward will be tapered to a uniform thickness of 4 in. The transverse armor at the after end of the belt and that part forward of the boiler space will be 12 in. thick. The main barbettes will have armor 15 in. thick reduced to 10 in. in the rear. The turret armor will be 14 in. thick throughout. From the armor belt to the main deck the ship's side will be protected by a 5 1-2 in. steel armor from barbette to barbette, and coal will be carried back of a considerable portion of this armor. A protective deck will extend the entire length of the vessel, 2 3-4 in. thick on the flat with inclined sides 3 in. thick forward and 5 in. thick aft. A cellulose belt is to be worked along the sides the whole length of the ship. The conning tower will be 10 in. thick with an armored communication tube 7 in. thick, and there will also be an armored station aft with 6 in. protection. In the wake of the 6-in. guns on the main deck there is to be continuous armor 5 1-2 in. thick extending between the turerts, and additional protection will be afforded by 1 1-2 in. splinter bulkheads between the guns. The 6-in. guns on the upper deck will be protected by 5 1-2 in. armor and

1 1-2 in. splinter bulkheads. The small guns will be protected by shields and extra side plating.

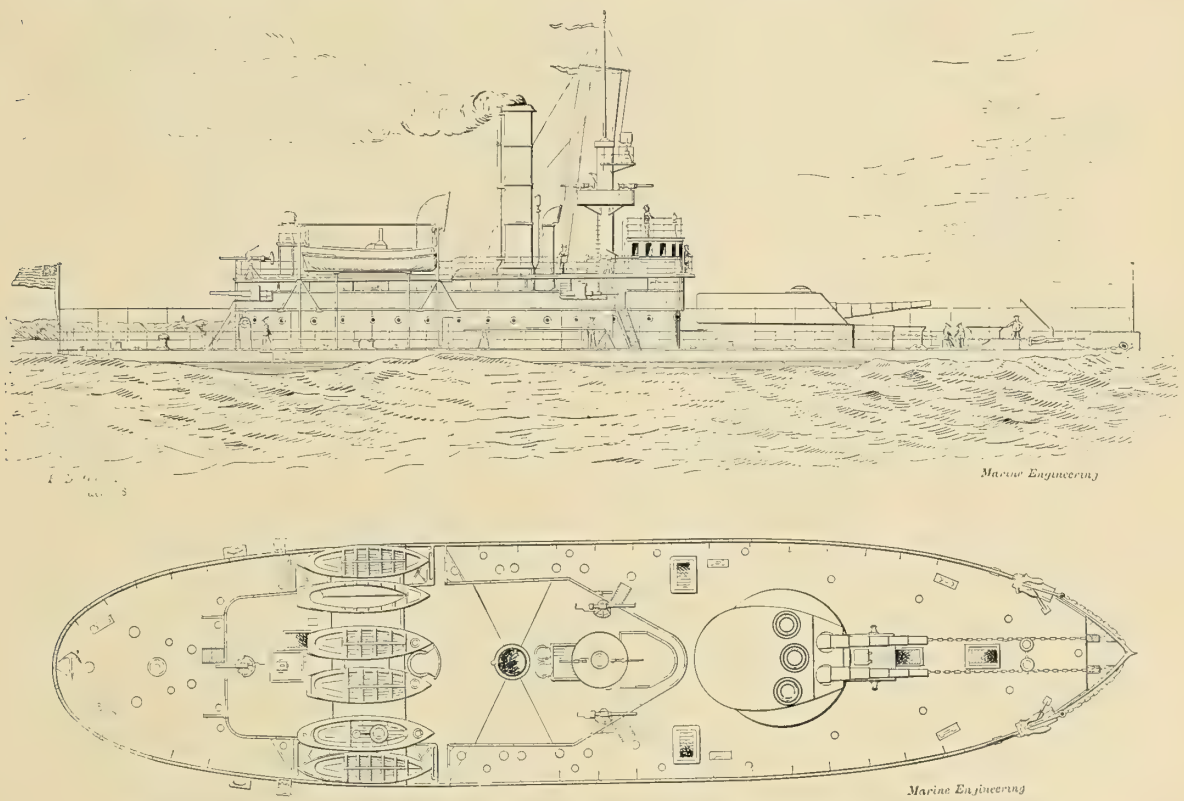
In addition to the main engines driving the twin screws there will be a most modern equipment of engine room auxiliaries and steam deck appliances.

The battery as outlined in the circular of the Department will consist of four 13-in. breech-loaders, two in each of the turrets on the mid-ship line; ten 6-in. rapid-fire guns broadside on the main deck and four on the upper deck within the superstructure, and a secondary battery of twenty-four rapid-fire and machine guns. The weight of guns and fittings is estimated as 574 tons, and the necessary ammunition 449 tons.

Harbor Defense Monitors.

The four harbor defense monitors called for in the Act of May 4, will present some of the most radical advances in modern fighting machinery. The monitor principle has always been distinctively American, and many experts regard the monitor as the best all around war ship yet designed.

The Act of Congress, appropriating for the naval service for the fiscal year ending June 30, 1899, under "Increase of the Navy," referring to the four harbor defense vessels of the monitor type, limits the cost of these vessels to $1,500,000 each. The limit of time of completion is twenty-seven months, with penalties for delay.



PROPOSED U.S. MONITORS ARKANSAS, CONNECTICUT, FLORIDA AND WYOMING.

Two submerged torpedo tubes will be fitted, and storage for eight 17 ft. torpedoes.

Electricity will be very extensively used on these ships. Not only will the turret turning gear be electrical, but also the ammunition hoists and the gear for training and loading the guns. Electric power will also be employed for driving ventilating fans and a variety of minor purposes. The generating plant will consist of eight units, each a direct connected set with an output of 400 amperes at 80 volts.

Provisions and small stores are to be carried for three months' supply and water allowance for fifteen days. Besides this an extensive distilling plant will be fitted. The complement of officers and crew will be 500 for each vessel.

The Navy Department, in the construction of this class of vessel securing the greatest results at the least expenditure of money, has in view not only the securing of the mainland harbors of the United States, but also of its island possessions in the Atlantic and Pacific oceans.

The design for the monitors, which have been named the "Arkansas," "Connecticut," "Florida," and "Wyoming," was prepared by Chief Constructor Hichborn. It was decided that the best all around arrangement that could be built with the available appropriation, was the arrangement with a single balanced turret on the center line forward, containing two high-powered 12 in. breech-loading rifles, a gun that has just been designed to be used with smokeless powder; four

4 in. rapid-fire rifles also to be used with smokeless powder, completes the main battery. The secondary battery will consist of three 6-pounder rapid-fire, and four, 1-pounder automatic rifles.

The general characteristics of these vessels as shown in the elements of design will be:

Length on load water line	225 feet
Breadth extreme at water line	50 "
Mean draft at normal displacement..	12 feet 6 inches
Normal displacement about.....	2,700 tons
Total coal capacity, loose stowage ..	200 "

In the details of design there will appear these characteristics.

The hull is to be of steel, not sheathed, with double bottom and close watertight sub-division.

There will be one military mast fitted with fighting and searchlight tops.

Seven boats are to be stowed clear of the blast of the guns, two being the lifeboats, which are to be carried at davits so as to be quickly lowered.

The protection of the hull against injury to the water line region is to be afforded by means of a side armor belt, the maximum thickness being 11 in., tapering to 5 in. at the armor shelf, the depth being 5 ft. The maximum thickness is abreast the engine and boiler spaces, from thence forward and aft it is reduced by steps to a minimum thickness of 5 in. at the bow and stern. The barbettes for the 12-in. guns will have armor about 10 in. thick.

The turret is of the Hichborn balanced type, with front plate inclined forty-two degrees from the vertical. The side plates of the turret armor are to be 9 in. thick. The main or protected deck is to extend throughout the length of the vessel, to be worked flat. The total thickness will be 1 1-2 in. A conning tower 7 1-2 in. thick having an armored communication tube 3 in. in thickness, will be carried in a suitable commanding position forward, the tube extending to the armor deck, and affording protection to the voice tubes, bell wires, etc.

Each vessel will be driven by twin screws. The engines (two in number) are to be of the vertical, triple-expansion type, in one watertight compartment. The high-pressure cylinder 17 in. dia., intermediate 26 1-4 in. dia., and the low-pressure 40 in. dia., with 24 in. stroke. The boilers (four in number) are to be of the water-tube type, constructed for a working pressure of 250 pounds, and are to be placed in one watertight compartment. There will be the usual auxiliary machinery and workshop tools.

Distilling apparatus and evaporators will be fitted for supplying fresh water.

The total coal bunker capacity will allow at least 200 tons with loose stowage, without trimming.

The total weight of machinery (but not including turret turning machinery, capstan, windlass, steering gear, or winches) is limited to 240 tons. Fifty tons of water for steaming purposes must be carried in the double bottom.

Steam windlass, steering engines and boat winches will be provided.

These vessels will have state rooms for the captain and for six officers, and will require a complement of crew of 125, for whom ample berthing space has been provided. Store rooms are provided for one month's supply of clothing, contingent and small stores.

The electric generating plant will consist of four units, each unit to have an engine, dynamo, and compensation bed plate, and each dynamo a rated output of 400 amperes at 80 volts.

The turret turning gear, ammunition hoists, elevating gear, rammers and ventilating apparatus, will be operated by electricity.

The estimated speed of the vessel is to be 12 knots—amply sufficient for a harbor defense vessel.

All wood used in the construction of the vessels will be fire proofed. The vessels will be fitted with docking keels, which will also serve the purpose of bilge keels.

These harbor defense monitors, which will have all the latest improvements known to naval science, will be important additions to the Navy, and being small, with large accommodations for crew for vessels of their size, they will be invaluable for the use and instruction of the naval militia. On October 1 bids for the construction of these monitors will be opened at the Navy Department, in Washington.

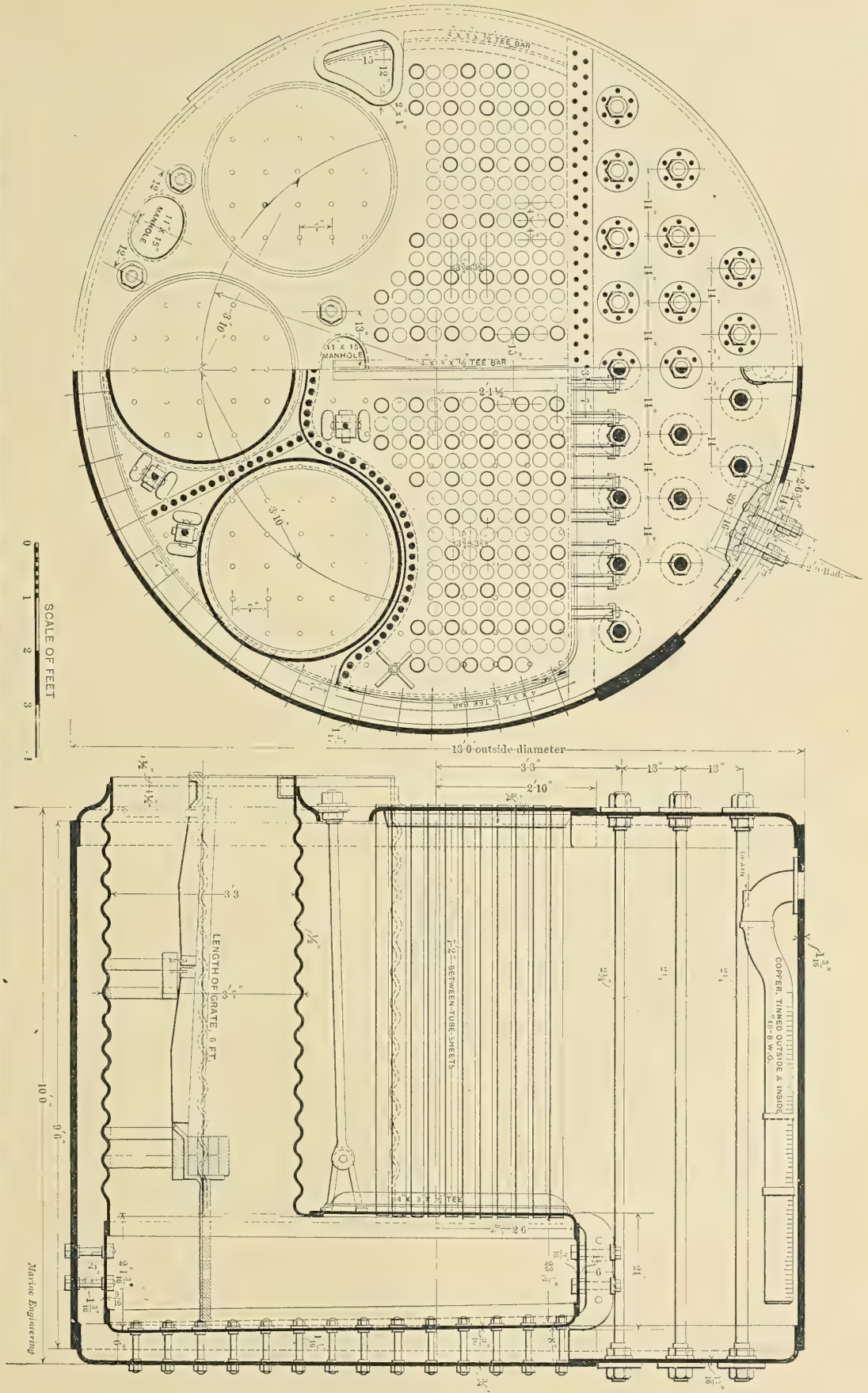
MACHINERY FOR THE NEW REVENUE CUTTER TO BE STATIONED AT NEW YORK.

A fine addition to the fleet of the Revenue Cutter service on the Atlantic coast will be made when the vessel now building at the Columbian Iron Works and Dry Dock Co., at Baltimore, is completed. This boat is officially known as No. 6, and is to be stationed at New York.

Her general dimensions are: length, over all, 188 ft.; between perpendiculars, 170 ft.; beam, molded, 29 ft.; and depth from base line at side amidship, 16 ft. 6 in. The displacement on 10 ft. draught is estimated at 706 tons. She is of very trim design, with high forecastle and poop, and is fitted with two masts schooner rig, and one smoke pipe, all of which have a slight rake.

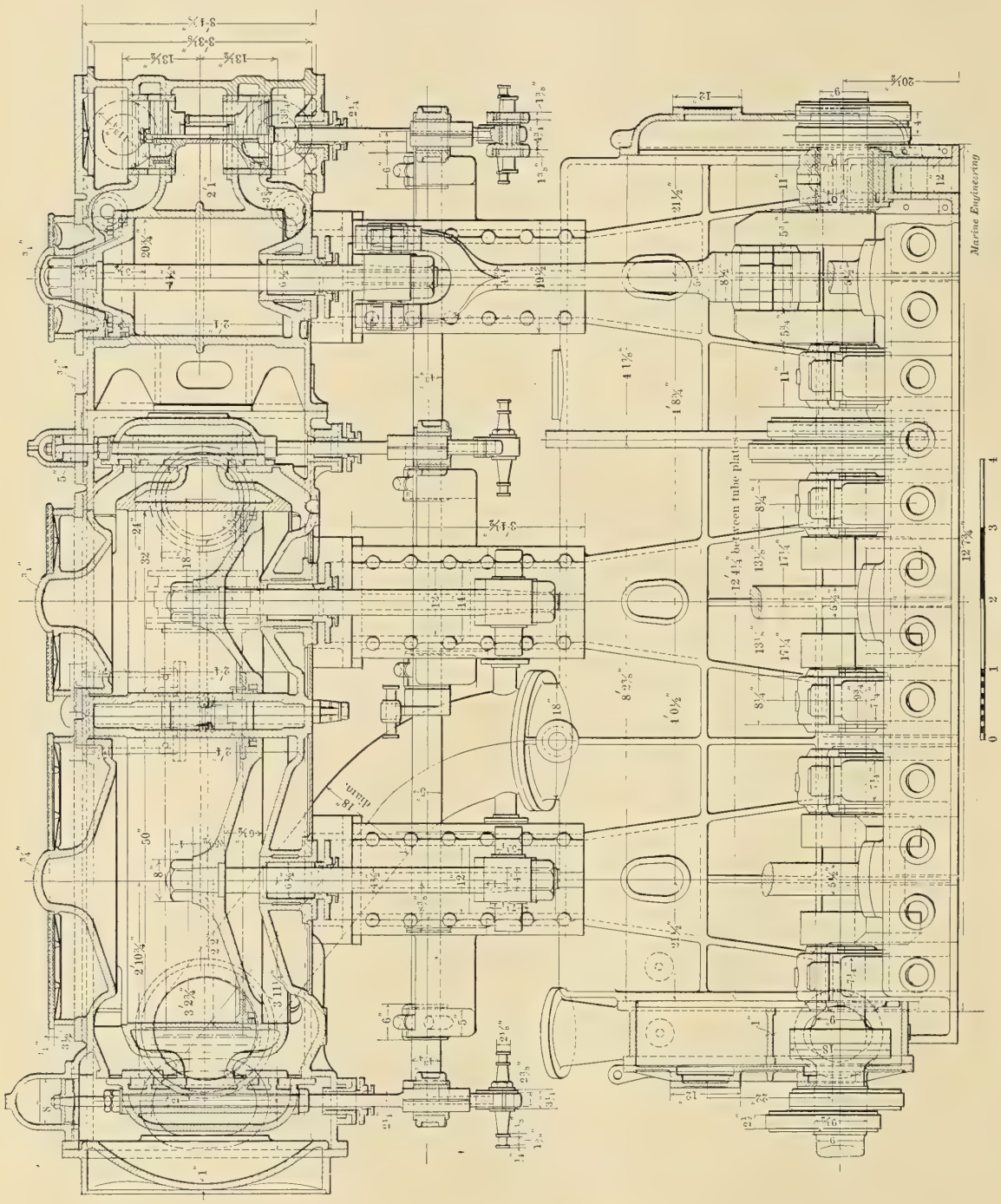
The accompanying illustrations show the designs of the engines and boilers of this vessel. These were drawn in the steam engineering bureau of the service at Washington under the supervision of Captain John W. Collins, Engineer-in-Chief of the Revenue Cutter Service. The engine is of the inverted triple-expansion type, designed for 1,500 I. H. P. The cylinders are 20 3-4 in., 32 in. and 50 in. dia. and 27 in. stroke. Piston valves are used for the high pressure cylinder and double ported slide valves for the intermediate and low pressure cylinders, all valves being worked by double bar Stephenson link motion. The engine framing consists of cast iron columns at the back

THREE FURNACE SINGLE-ENDED FIRE-TUBE BOILERS FOR NEW REVENUE CUTTER DESIGNED BY ENGINEER DEPT. U.S.R.C.S.



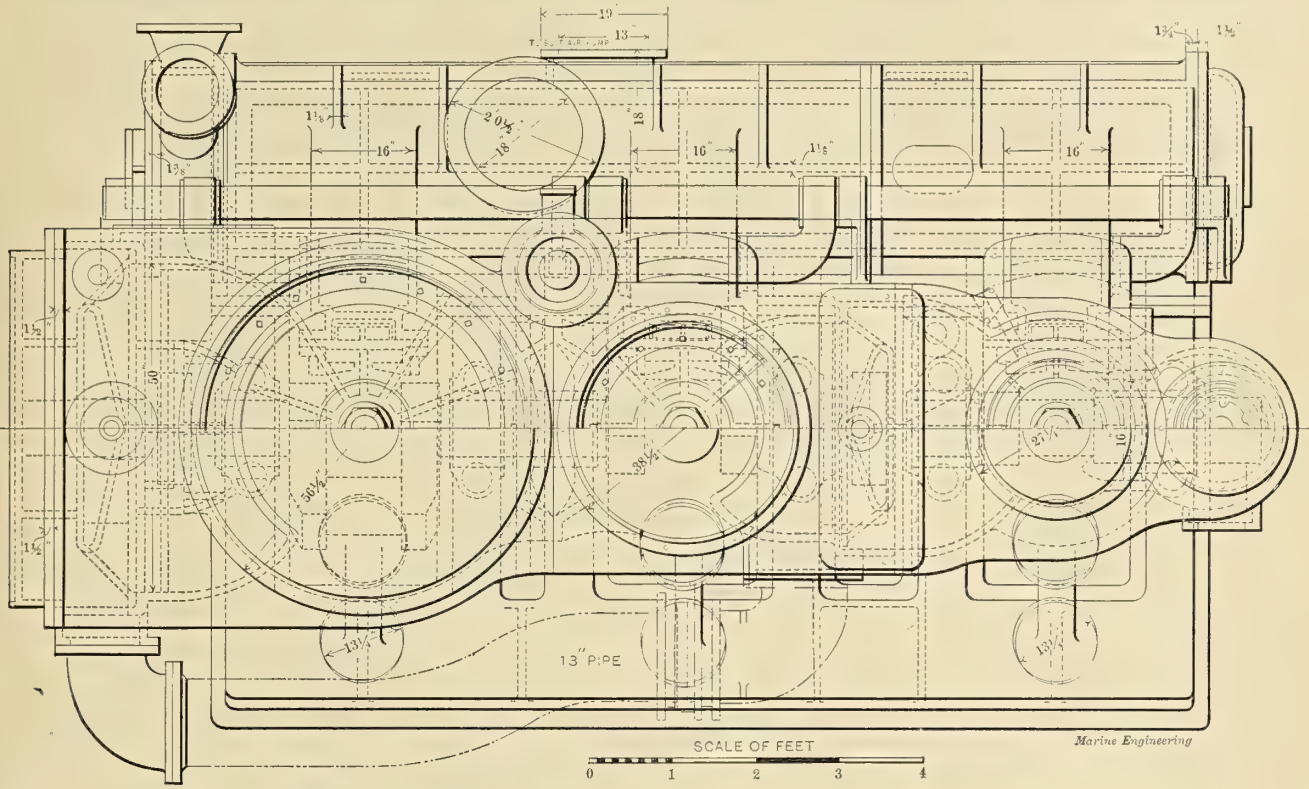
carrying single slippers, and wrought steel turned columns in front. The back columns are cast on the main condenser, this forming part of the framing. The bed plate is cast iron. The crank, line and propeller shafts are forged mild open-hearth steel, and are solid, and the piston rods, connecting rods and other working parts are of forged high-tensile open-hearth steel. All stuffing boxes will be packed with Katzenstein's metallic packing.

Some of the details of design of interest follow: Cylinder clearances, 3-8 in. between upper heads and pistons, and 1-2 in. between lower heads and pistons. High pressure valve: steam lap, top, 1 3-8 in., bottom, 1 3-16 in.; exhaust lap, top, minus 3-8 in.; bottom, zero. Intermediate slide valve: steam lap, top, 1 15-16 in., bottom, 1 1-16 in.; exhaust lap, top, minus 3-16 in. bottom plus 3-16 in. Low pressure slide valve: steam lap, top, 1 27-64 in., bottom, 1 15-64 in.; exhaust lap,

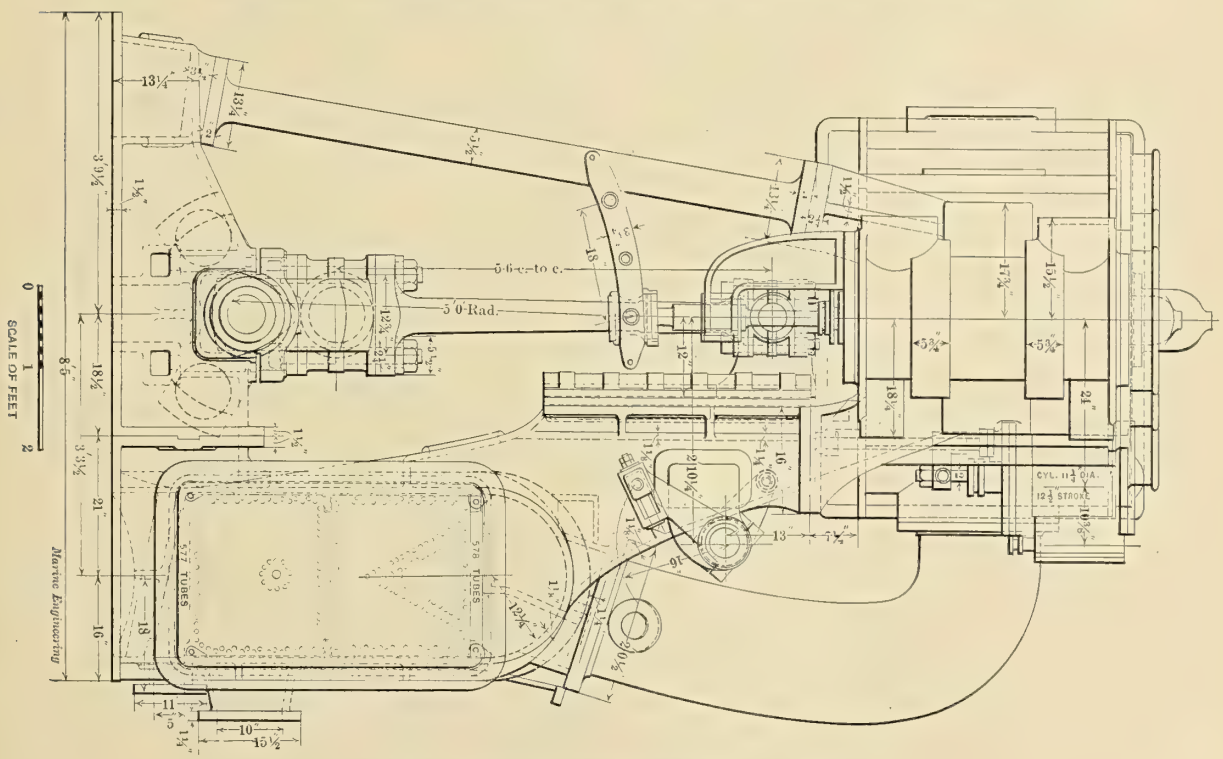


TRIPLE-EXPANSION ENGINE FOR NEW REVENUE CUTTER TO BE STATIONED AT NEW YORK.

top, plus 9-32 in., bottom, plus 19-32 in. Eccentrics of cast iron, the I. P. and L. P. in two parts and the H. P. solid. The reversing gear will consist of a steam cylinder 11 1-4 in. dia. and 12 1-2 in. stroke, placed vertically, and secured to the I. P. and L. P. cylinders. All journals will run in composition boxes, lined with Parson's white metal. The crankshaft is in two sections, with



PLAN OF TRIPLE-EXPANSION ENGINE FOR NEW REVENUE CUTTER.



END ELEVATION HIGH-PRESSURE CYLINDER.

cranks set 120 deg. apart. In the bearings the journals measure 9 in. dia. and 11 in. long, and the pins 9 in. dia. and 11 1-2 in. long. The webs are 11 1-2 in. wide and 5 3-4 in. thick, chamfered at the pin ends.

The thrust shaft is 9 in. dia., with nine collars 1 11-16 in. wide, with spaces 3 3-8 in. The collars are 14 1-2 in. outside dia. The intermediate shaft will be 9 in. dia. and the propeller shaft 9 1-2 in. dia.

The main engine condenser is rectangular in shape, cylindrical at the top and sloping at the bottom, and is made of cast iron 1 1-8 in. thick. The dimensions are about 12 ft. 4 1-4 in. between tube sheets, 2 ft. 0 1-2 in. wide, and 5 ft. high—inside measurements. The tube sheets are of composition 7-8 in. thick, and there are in all 1,155 Muntz metal tubes 5-8 in. O. D. tinned inside and out. The tubes are spaced 15-16 in. between centers. The total cooling surface is about 2,343 sq. ft.

Manganese bronze is used for the screw propeller, which is right handed with four blades, in dia. 9 ft. 6 in.

Two single-ended Scotch boilers will be fitted. These are 13 ft. outside dia. and 10 ft. long, over all, and are designed for 160 pounds pressure. They will be placed in a watertight compartment in one fire room. Each boiler has three corrugated furnaces 3 ft. 3 in. inside dia. The total heating surface is 3,392 sq. ft. and grate surface 112 sq. ft.

Besides steam for the main engine these boilers will supply the independent air pump and other auxiliaries. These will include a James Reilly distilling apparatus with a capacity of about 3,500 gallons of potable water in 24 hours. A centrifugal circulating pump with engine having an 8 in. by 8 in. steam cylinder will be fitted. The duplex feed pump will have steam cylinders 8 in. dia., water cylinders 5 in. dia. and 12 in. stroke. An auxiliary feed pump, a bilge pump, a distiller pump, an air compressing pump for the sanitary system, and a distiller circulating pump will also be included. A bilge ejector will have a 3 1-2 in. discharge. Other apparatus will comprise an ash ejector and machine tools in a small engineer's workshop.

There will be arrangements for the use of forced draft, on closed fire room system, for use in case of necessity. A direct acting engine will drive the blower.

Work on the vessel is well advanced, and she is expected to go into commission this year.

The welcome announcement that the Maryland Steel Co. would resume work in the Sparrows Point Shipyard was made last month. Work will be started with the construction of the torpedo boat destroyers which have been successfully bid on. This plant, as many of our readers are aware, is one of the most complete and best equipped in the country. Andrew G. Wilson is general superintendent.

REPORT UPON THE CONDITION OF ADMIRAL CERVERA'S VESSELS.

AFTER AN EXAMINATION BY A BOARD OF UNITED STATES NAVAL OFFICERS.

Special Attention Given to the Effects of Our Gun Fire, of Combustible Material, and Explosions—Sketches Showing Number and Location of Hits—Conclusions Drawn by the Board.

Soon after the naval fight at Santiago July 3, which resulted in the destruction of the Spanish vessels under command of Admiral Cervera, a board of U. S. naval officers was appointed by Admiral Sampson to inspect the three ships which were beached and burned. (Infanta Maria Teresa, Almirante Oquendo and Vizcaya), and also the sunken vessel Cristobal Colon. The members of the board were: Lieutenant Commander R. P. Rogers, Lieutenant Commander N. E. Mason, Lieutenant R. F. Nicholson, P. A. Engineer G. W. McElroy, P. A. Engineer F. M. Bennett, Lieutenant F. J. Haeseler, Lieutenant E. E. Capehart, Asist. Naval Con. R. P. Hobson.

They were instructed to report especially upon the effects of gun fire, of combustible material and explosions and also upon the feasibility of raising and saving the Cristobal Colon. The board immediately began a survey of what remained of the once splendid warships, which were lying at intervals on the Cuban shore west of Santiago; the farthest, the Cristobal Colon, lying at Rio Tourquino, a distance of 48 miles.

We here publish the intensely interesting report in full. Immediate note may be made of the general conclusions reached by the naval experts which are as follows:

The ships Infanta Maria Teresa, Almirante Oquendo and Vizcaya were destroyed by conflagration, caused by explosions of shells in the interior and setting fire to the woodwork. The upper decks, and all other woodwork, are entirely consumed, except at the extremities.

Many of the guns on board the burned ships were found loaded at the time of the Board's visit, indicating the haste with which the crews were driven from their guns.

The conclusions drawn by the Board from its examination of the captured Spanish ships are:

That the use of wood in the construction and equipment of warships should be reduced to the utmost minimum possible.

That loaded torpedoes above the water line are a serious menace to the vessel carrying them and that they should not be so carried by vessels other than torpedo boats.

That the value of rapid-fire batteries cannot be too highly estimated.

That all water and steam piping should be led beneath the protective deck or below the water line and fitted with risers at such points as may be considered necessary.

In the sketches which accompany the report, the approximate number and size of shot holes in the vessels are graphically displayed, and the location of the vessels, the Cristobal Colon

and Infanta Maria Teresa, on the beach are also shown.

The members of the Board express their indebtedness to Captain L. W. T. Waller, U. S. Marine Corps, for the photographs of the vessels which now form part of the report. Captain Waller served with distinction on the battleship Indiana during the Santiago engagement, and as soon as conditions on the wrecked vessels made it possible he went aboard and took a large number of photographs, showing in detail the awful destruction caused by our hits and the subsequent fires and explosions. Through the courtesy of Captain Waller we are able to here reproduce a number of the most striking of these now historic views.

To facilitate the ready application of the report to purposes of analysis we have prepared the tables here printed showing both the number

APPROXIMATE NUMBER OF SHOTS WHICH TOOK EFFECT ON THE SPANISH VESSELS IN THE SANTIAGO FIGHT.*

Spanish Warships.	Size of U. S. Guns.									
	13-inch.	12-inch.	8-inch.	6-inch.	5-inch.	4-inch.	6-pdr.	3-pdr.	1-pdr.	Total.
Viscaya	....	....	5	....	6	4	13	....		28
Oquendo	....	1	4	5	2	7	44	...	....	63
Teresa	....	2	3	....	4	1	16	....	1	27
Colon	....	....	....	....	3	....	4	....	....	7
Total	...	3	12	5	15	12	77	....	1	125

*Not including the shells which sunk the torpedo-boat destroyers Pluton and Furor.

SHOTS FIRED BY U. S. SHIPS DURING THE NAVAL ENGAGEMENT AT SANTIAGO, JULY 3, 1898.

U. S. Ships.	Size of Guns.									
	13-inch.	12-inch.	8-inch.	6-inch.	5-inch.	4-inch.	6-pdr.	3-pdr.	1-pdr.	Total.
Oregon	36	....	145	..	....	....	1500	....	....	1681
Iowa	....	31	35	....	....	251	1056	....	100	1473
Brooklyn	....	....	100	....	473	....	1200	....	200	1973
Gloucester	....	....	....	....	....	....	589	780	....	1369
Texas } Indiana }	11	8	31	171	....	....	2208	....	....	2429
Totals	47	39	311	171	473	251	6553	780	300	8925

of shots fired by the U. S. vessels named and the approximate number of hits, as ascertained by the Board and by independent experts.

REPORT OF THE BOARD.

Following is the complete report of the Board of examination in the original text:

Infanta Maria Teresa.

CONDITION OF HULL.

Condition of Flotation—The vessel is nearly upright, laying without appreciable angle of keel, at a watering line differing from the L. W. L. by trimming about five feet by the stern. Flooding is practically complete, fore and aft, and may have been brought about by water entering above the protective deck through the stern torpedo tubes, and the broken joints of the waist torpedo tube castings. This is indicated by the swash in the present condition of the vessel. The vessel rests easily, bearing upon the bottom throughout the greater part of her length. Soundings show the bottom to be firm coral sand, shelving gently more or less, as indicated in the sketch here printed. (Page 18.)

Structural Solidity—The examination extended inside to the portion above protective deck, and included the outside complete, excepting the portion resting on the bottom. Diving between the hull was impracticable under the conditions.

Skeleton Frames—The frames above water are practically intact, having only deformation more or less moderate due to heat. They are doubtless intact below water, there being no evidence of bulging. For purposes of solidity they may be considered practically intact.

Deck Beams—The deck beams above water are generally more or less warped by the heat. The warping is more or less pronounced in portions where the wood flat had no metal flat below, notably on the main or upper deck and on the gun deck forward and abaft the engine and boiler spaces. In cases of supporting local weights, as windlasses, etc., the deformations were pronounced. The beams have sagged and dropped to such an extent as to destroy their structural usefulness. The stanchions have been affected in practically the same manner as the beams; warping being more pronounced in the 'tween decks, between the upper and gun deck. Generally speaking the fastenings of the beam arms are sound. Below the protective deck the deck beams are doubtless intact.

Bulkheads—The bulkheads above the protective deck were principally of wood and played but slight structural role in the normal condition. Those of metal—limiting the upper coal bunkers—are badly warped. Below the protective deck the bulkheading, longitudinal and transverse, is doubtless intact.

COVERINGS.

Outside Coverings—Generally speaking, the outside plating for structural purposes may be considered intact. There is warping, though not pronounced, in the upper portions subjected to heat. Divers' reports show an intact condition below the water as far as the examination could be extended. The portion resting on the bottom, extending over the greater part of the length below the bilges, except at the ends, could not be examined; but taking account of the extended evenness of the bearing surface, there is probably little deformation, and without appreciable injury to solidity.

Deck Plating—All deck plating above the protective deck, including the stringers and tie-plates, have been more or less warped and the fastenings impaired by the heat from the burning of the wooden deck-flat. Excepting the usual junction of stringer and tie plates, the deck plating above the protective deck is but slightly developed, and plays but small part of structural solidity in the normal condition.

In sum, taking full account of the distribution of the weights and the strains involved, and taking full account of the reduction of strength, as pointed out, it is considered that with an intact condition of internal structure below the protective deck, the remaining structural solidity is adequate for the stresses liable to be encountered in wrecking the vessel and those liable to be encountered in any except severe conditions of navigation. Occasion may be taken to point out that the vessel has suffered more as a longitudinal girder than a transverse girder, and that in a heavy sea it would be on the side of security to avoid the position of steaming head to sea.

It should be pointed out that, on account of the local weaknesses entailed by warping as described above, it would be on the side of security to remove the heavy guns and turrets and the conning tower before the vessel be sent to sea.

Effect of Internal Explosions—There are no indications of any internal explosions having occurred on this vessel. All deformations found can be accounted for by the heat effect of conflagration.

CONDITION OF ORDNANCE EQUIPMENTS, ETC.

The 11-inch guns and mounts are in an excellent condition, requiring only such care as is necessary to protect them from the injurious effects of the elements.

The 14 cm. guns require new breech blocks on every gun except two. With cleaning, overhauling and slight repairs, these guns may be put in a serviceable condition.

The shield of the second gun on the port side has been perforated by an 8-inch shell.

The secondary battery is badly burned. The only portions which can probably be made serviceable are the 6-pounder barrels.

The magazines, being below the protective deck, are flooded and inaccessible; but are apparently intact.

The torpedo outfit is so badly damaged by shot and fire as to be ruined. Apparently no torpedoes were exploded.

CONDITION OF MACHINERY AND BOILERS.

The engines are covered with water to within six inches of the tops of the cylinders, and an examination of them, therefore, can not properly be made. From what can be seen, exploding shells have not struck them, and they are believed to be intact.

It can not at present be determined if any of the cylinders or heads are cracked from heat.

If the vessel is raised soon, the engines can probably be made serviceable with such work done upon them as is usually necessary to put submerged machinery in order.

The water also prevents an examination of the boilers, and a definite knowledge as to their condition can not be obtained. All gratings are in place, and there is no evidence in the trunks or other approaches to fire rooms of any boiler explosions having taken place. The boilers, however, are subjected to extreme strains, due to sudden cooling, and the tubes will probably be found to have started even if there be no greater derangement.

All the piping above the protective deck has been warped, melted and otherwise destroyed by heat.

The coal bunkers of this vessel, as well as all the others except the Cristobal Colon, were, on the 9th of July, still on fire and smouldering.

EFFECT OF GUN FIRE.

The effect of the gun fire upon the Infanta Maria Teresa was noted as follows:

Commencing at the bow on the port side:

One 6-pounder, just under the after hawse pipe on the gun deck, ranged aft; and one just below it on the berth deck in the same direction.

Two 6-pounders—one ranging aft and one forward—passed through the foremast.

One 4-inch entered the berth deck from forward just below the forward 14 cm. gun; passed across the deck and exploded.

One 6-pounder struck normal and entered the berth deck about six feet abaft the 4-inch shot just mentioned.

One 6-pounder shell struck between the forward 5.5-inch (14 cm.) and the next one to it on the gun deck and ranged forward.

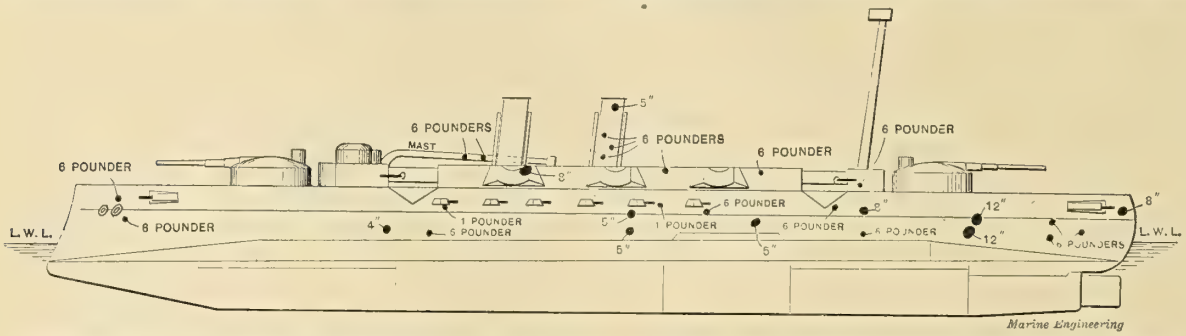
An 8-inch shell struck the shield of the second 5.5-inch (14 cm.) gun, passed through it, ranging aft and exploded. The effect of the explosion upon almost everything about the decks in that vicinity must have been terrific.

One 6-pounder passed through the ventilator just forward of the after smokestack.

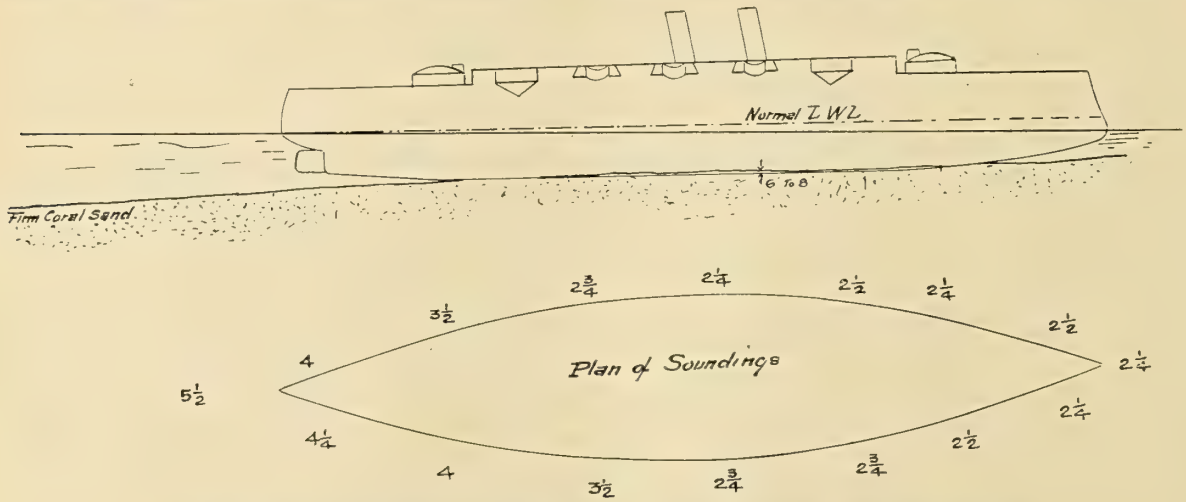
The after smokestack has a 5-inch shot hole through it, ranging from aft forward, and also three 6-pounder shot holes in the same direction.

Just abaft the after smokestack under the berth deck is a hole from 5-inch shell which ranged from forward aft. It passed through the wing passage into a coal bunker, where it exploded. The fragments ripped up the gun deck in the vicinity.

A 5-inch shell also passed into the gun deck at the same point and exploded, doing great damage in the vicinity.



INFANTA MARIA TERESA—APPROXIMATE LOCATION OF HITS AND PROBABLE SIZE OF PROJECTILES.



SKETCH SHOWING POSITION OF INFANTA MARIA TERESA ON THE BEACH.

One 6-pounder passed through the superstructure just abaft of the after smokestack.

One 1-pounder passed in just above the berth deck, normal to the surface and across the deck.

A 6-pounder passed through the side of the gun deck, between the two after 6-pounder guns, normal to the surface.

A 5-inch shell passed into the berth deck and exploded just under the same.

A 6-pounder passed into the berth deck under the after 14 cm. gun, and another shell of the same caliber passed through the after side of the superstructure on the port side, ranging forward, and normal to the surface.

An 8-inch shell struck the gun deck just under the after barbette; passed through the skin of the ship and exploded, ranging aft. The damage done by this shell was very great. All the men in that locality must have been killed or badly wounded. The beams were torn and ripped, and the longitudinal bulkheads between the two cabins was badly damaged. The fragments of this shell passed across the deck and out through the starboard side at an angle of 45 degrees. This shell also cut the fire main.

One 6-pounder entered on the berth deck, just under the 8-inch shell previously mentioned, striking normal to the surface.

Two 12-inch shells entered just under the berth deck. They entered through almost the same hole, the holes slightly overlapping. They exploded in the stern torpedo manipulating room, cutting the beams of the berth deck on the port side away from the frames, completely wrecking everything in that compartment, and made a large, ragged hole about four feet square on the starboard side. They both entered at an angle of about 45 degrees with the normal, ranging from aft forward.

One 6-pounder entered the gun deck, from aft forward, just above the holes made by the 12-inch shells.

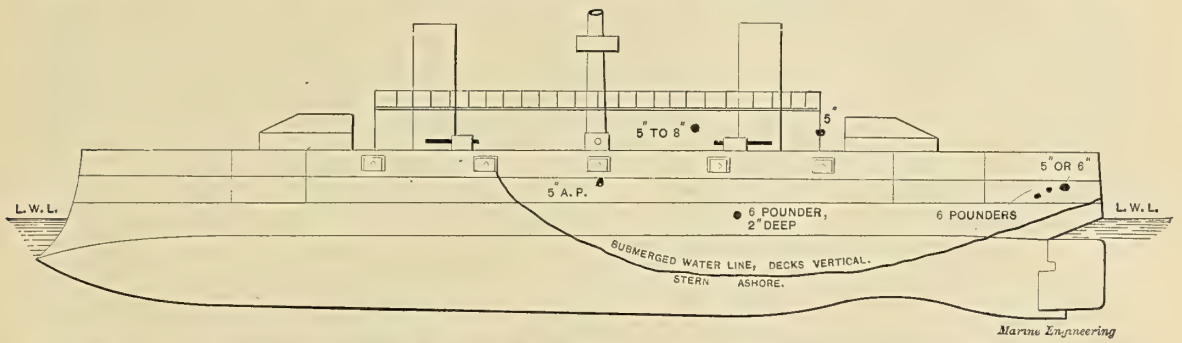
One 6-pounder entered the berth deck just to the right of the same place. The last one ranged from forward aft.

An 8-inch shell struck just abaft the sponson of the after 6-pounder, going straight through, and out the other side in the corresponding locality, without bursting.

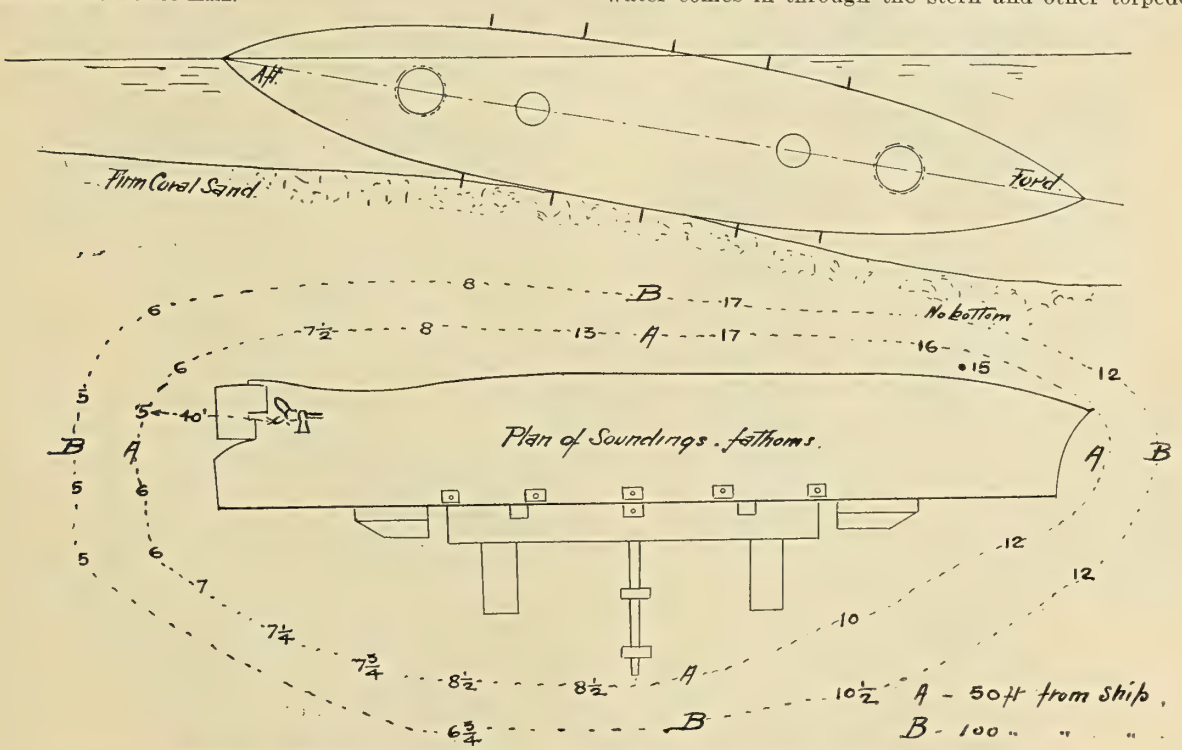
It was not practicable to locate any shot holes in the portion of the ship now under water.

CONCLUSION.

The structural solidity of this ship is not to any considerable degree injured. Barring local distortions, the hull is practically intact. The outside skin is reported by divers as intact, so far as holes are concerned. The examination extended to the bilges, fore and aft, and, in some parts near the extremities, to the bottom. The lower portion of the vessel, up to the protective deck, is filled with water. The water comes in through the stern and other torpedo tubes. The board is therefore of the opinion that it is possible and desirable to float the Infanta Maria Teresa. The vessel is lying about 100 yards from the beach, in a small cove, about five miles west of the Morro, and is grounded for the greater part of her length. The vessel lies in a very good position, with deep water astern to facilitate pulling her off. She is fairly well protected against an easterly sea. The after mast and also the funnels



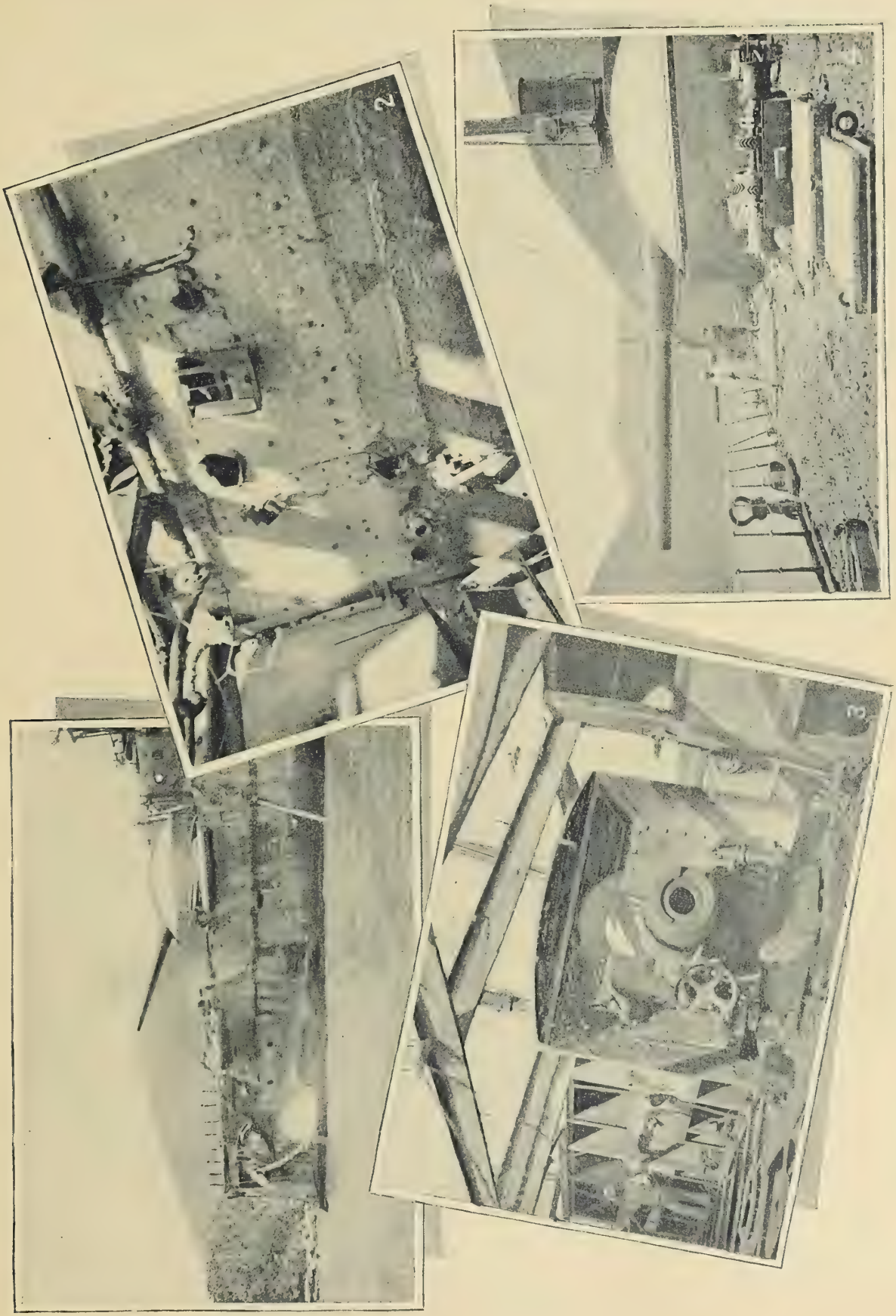
CRISTOBAL COLON—APPROXIMATE LOCATION OF HITS AND PROBABLE SIZE OF PROJECTILES.



SKETCH SHOWING POSITION OF CRISTOBAL COLON ON THE BEACH.

From Photographs taken by Captain L. W. T. Waller, U. S. Marine Corps.

U. S. OFFICIAL VIEWS OF THE WRECK OF THE CRISTOBAL COLON.—REPRODUCED BY PERMISSION.—FOR DESCRIPTIONS SEE PAGE 22.



From Photographs taken by Captain L. W. C. Walker, U. S. Marine Corps.

U. S. OFFICIAL VIEWS OF THE WRECK OF THE INFANTA MARIA TERESA.—REPRODUCED BY PERMISSION.—FOR DESCRIPTIONS SEE PAGE 22.

Cristobal Colon.

The Board found the Cristobal Colon lying on her starboard beam ends, the stern being about 150 feet from the shore, and her length lying in a direction nearly perpendicular to the line with the beach. The vessel lies several hundred yards to the westward of Rio Tourquino. The depth of water at the stern is between five and six fathoms; the bow lies in a depth of about 16 fathoms. The deck is quite vertical. The battery on the port side, with the exception of the two forward 6-inch guns, is clear of the water. The forward and second 6-inch ports are submerged. The rest of the gun ports on the port side are out of water. The bottom valves are supposed to be open. Many of the watertight door were closed by the crew of the Oregon before the vessel capsized. The bilge-keel is exposed, and also the port propeller and the propeller shaft.

CONDITION OF HULL.

The Condition of Flotation.—The vessel lies on her starboard beam ends, perpendicular to the beach, stern inshore, with about 200 feet of her length from the stern out of the water, the maximum height of deep angle above water being about 12 1-2 feet, this occurring at about 30 feet rom the stern. stern. Apparently flooding extends throughout. Soundings indicate a firm coral sand bottom, shelving off shore. The vessel lies more or less easily, working slightly from right to left, as is to be expected from the short length of bearing surface. Examination was limited to the above-water portion. Diving was not practicable under the circumstances.

Structural Solidity—There is no deformation visible in deck or outside plating, except some dents where rocks had touched the bottom, and there is no indication of the vessel's having sustained any structural injury. The side armor gives good guarantee against local injury to the surface bearing on the bottom, and there is reason to believe that, with the integrity of the skin plating and of the decks and transverse bulkheads, the vessel can sustain herself in the present position, even in a heavy surf, without serious injury. The conditions, however, would change rapidly for the worse, with a change of direction of heading, or with movement off shore. There is no evidence of any internal explosion. Taking full account of the conditions of flotation and of the probable conditions of structural solidity, it is considered advisable that effort should be made to raise and save this vessel.

CONDITION OF ORDNANCE EQUIPMENTS, ETC.

The magazines of the Cristobal Colon and the ordnance equipment of the ship we found to be as follows: The magazines are submerged, and are supposed to be intact. The battery, apparently, is intact, with the exception of the breech locks, which are gone in most of the guns; some few remain. The guns cannot be removed in the present position of the ship.

CONDITION OF MACHINERY AND BOILERS.

It was impossible to inspect any parts of the engines and boilers, the vessel lying on her side and three-quarters submerged. As soon as raised, the machinery can probably be saved.

There is no record, or evidence, of any boilers having exploded. It is thought that the vessel was sunk after surrender, by opening sea valves and breaking their casings. After having been in the water some time, the working parts will be in bad condition, and will require the usual overhauling that any machinery would need after having been submerged.

EFFECT OF GUN FIRE.

The following hits were found on the port side of the hull and the superstructure of the Cristobal Colon:

About 12 feet from the stern, and 4 feet above the water line, one 5 or 6-inch projectile pierced the plating at an angle of about 45 degrees from the stern. This projectile came out through an air port on the starboard side, as observed before the vessel sank.

One 6-pounder struck flat below the above-mentioned spot, and above the armor belt.

One 6-pounder penetrated the plating above the armor belt, directly beneath the 5 or 6-inch above mentioned.

Between the 5-inch or 6-inch and the 6-pounder above mentioned another 6-pounder struck, without penetrating.

A 5-inch armor-piercing projectile struck the armor at the junction of No. 3 6-inch sponson, at an angle of about 45 degrees from aft. It penetrated nearly through, and the projectile rebounded.

One 6-pounder shell struck in armor below No. 4 6-inch gun sponson; impact normal; penetration two or three inches.

One 5-inch shell through the superstructure plating above No. 3 6-inch sponson.

It is reported that a projectile entered the after superstructure on the port side. Dimensions not known.

CONCLUSION.

The Board recommends that as soon as possible the Cristobal Colon should be secured by cables and anchors so that she cannot be moved from her present position. The Board recommends that the wrecking companies be directed to arrive at the earliest moment with all the facilities possible to wreck the Cristobal Colon, and is of the opinion that, if the weather continues favorable, the probabilities are good for saving the vessel.

As we go to press word has been received by the Navy Department from Captain Goodrich, commanding the cruiser Newark in Cuban waters, that the Infanta Maria Teresa has been raised and is now at Guantanamo. There she will be overhauled and put in condition to be brought to the New York or Norfolk Navy Yard.

(Report to be continued.)

Descriptions of the Official Photographs of Spanish Warships Wrecked and Sunk at Santiago, in the Naval Engagement July 3, 1898, Reproduced on Pages 20 and 21.

CRISTOBAL COLON.

1. Looking from off the bow.
2. Port screw and shaft jacket.
3. Looking forward.
4. Showing decks, guns pointing upward.

INFANTA MARIA TERESA.

1. View of wreck from bow to bridge.
2. Showing shot holes through coal bunkers. One exploded, setting fire to coal.
3. Showing 5.5 in. gun shield pierced by 8 in. shot. Crew killed. Dark object to left and below shield is a charred body.
4. Port side quarter deck, showing 11. in gun turret.

An order for a new steam yacht has been placed by P. A. B. Widener, of Philadelphia, with the Neafie & Levy Co., of that city, to replace the former vessel of the name Josephine sold to the Government as an auxiliary gunboat and renamed the Vixen. The new vessel is to be 216 ft. long, 257 ft. over all; 30 ft. 3 in. beam, and 18 ft. 6 in. deep from main deck. She will be fitted with two masts schooner rig. She will have a single screw driven by a quadruple-expansion engine, with cylinders 19 1-2 in., 28 in., 39 in., and 57 in. dia. and 36 in. stroke. Two Scotch boilers will supply steam of 200 lbs. pressure and there will be bunker capacity for 240 tons.

HIGH PRESSURE AT SEA WITH SOME CONSIDERATION OF TYPES OF BOILERS.—V.

BY W. R. CUMMINS.

In the boilers under question the gases, after leaving the combustion chamber, are well split up and distributed over the heating surface, but the distance traveled by the gases before they pass into the uptake is so small that it will be impossible to lower the temperature of the gases to an economical point. For instance, the mean distance traveled by the gases from the firebars to the uptake is only about 5 ft. in the Yarrow boiler, and somewhat more in the other varieties, against 17 ft. in the Scotch boiler. As regards weight of water over the highest heating surface, these boilers are so deficient that an automatic feed arrangement is desirable. For instance, in the three boilers taken as an example the weight of the water at 6 in. over the highest heating surface is about 2,625 lbs.; that is to say, the surface would be exposed if the feed were shut off for only ten minutes. These boilers are very accessible for cleaning, examination, and repairs, except those with curved tubes. As the whole of the surface exposed is composed of tubes, it is an easy matter to renew the whole or any part of them. All these boilers have lower drums shielded from the heat of the furnace, where grease and mud may collect without doing harm. The circulation of water in these boilers is natural, and leaves nothing to be desired. This, combined with their form, renders straining from unequal temperatures impossible, and allows steam to be raised in a very short time without the trouble of mechanical circulation. Finally, as to cost of construction, they should be one-half that of a Scotch boiler of the same heating surface and grate.

Hence boilers of this type, if built with straight tubes of fairly large diameter, would fulfil all the conditions enumerated before as necessary for a good boiler, except that of the time the gases are exposed to the heating surface, and the weight of water above the highest heating surface; the first point largely affecting the fuel economy, a very vital consideration with boilers for the mercantile marine, and the second point affecting the ease and confidence in working. The other class of water-tube boilers, comprising the Belleville, the D'Allest, the Babcock & Wilcox, and the Niclausse, have as a common feature rows of water tubes slightly inclined to the horizontal, with their ends connected in various fashions to "headers," in order to effect the circulation of water through the tubes.

As regards the thickness of the heating surface, these boilers are under the same favorable conditions as the other class of water-tube boilers. As regards size of combustion chamber, they are, generally speaking, deficient. For instance, take three Belleville boilers of the same grate surface (118 sq. ft.) as the two Scotch boilers we have been using as examples. The volume of the combustion chambers for these three boilers amounts to only 255 cu. ft., against 480 cu. ft. for the Scotch boiler, and 525 cu. ft. for the other class of water-tube boilers. Besides the deficiency in volume, they are of insufficient height, the consequence being that whenever fresh fuel is put on, some of the liberated gases reach the lower row of tubes before they have time to get heated up and combined. They pass among the tubes unconsumed until they reach the uptake. If they meet a hot current of gases from another boiler they will burn in the uptake; if not, they will pass up the funnel unconsumed. The former event is probably what happened during the first trials of H. M. S. Powerful, when the base of the funnel became red-hot. The evils of a shallow combustion chamber are aggravated by a thick fire, and to get good results with a combustion chamber of this type needs a thin fire and firing little and often.

One of the features of the Belleville boiler is the arrangement of air jets above the firebars. These jets serve two purposes: First, they tend to secure a better combustion than would otherwise be possible; and, secondly, they tend to protect the lower row of water tubes, which apparently sometimes suffer from overheating. As regards the splitting up of the gases after leaving the combustion chamber, and their distribution over the heating surface, the boilers of the type we are considering are quite equal to any of the types before considered, and as regards the distance traveled by the gases, before they pass away to the uptake, they are very superior to the other class of water-tube boiler. For instance, in the three Belleville boilers used as before for comparison, the mean distance traveled by the gases from the firebars to the uptake is about 9 ft., compared with about 5 ft. in the Yarrow boiler.

As regards the weight of water carried above the highest heating surface, this type of boiler is provided with a drum connected with the front and back headers, and if the drum is of sufficient capacity, a large weight of water can be carried over the highest heating surface. The Belleville boiler is, however, worked in a special manner and requires a feed regulator. As regards accessibility and convenience for repairs, this class of boiler is very well off, except, perhaps, in the matter of cleaning the tubes externally, especially in cases where deflectors are placed on the tubes. The tubes are all straight, of large diameter, and uniform length, thus dispensing with the necessity of carrying a great number of spare tubes and allowing for internal inspection of each tube. A majority of these boilers are provided with a mud drum at the bottom, where sediment may collect and be removed at intervals. The circulation of water in this class of boiler is satisfactory, provided the tubes are of sufficiently large diameter, and the fires are not much forced. With small tubes and forced draught there is a risk of burning the lower tubes, owing to failure

of the circulation. If there is any risk of this, and the headers are in one piece from top to bottom, they should be sufficiently flexible to allow for the unequal expansion of the top and bottom rows of tubes, as cases have happened of cracked headers due to this cause. As regards cost of construction and space occupied, this class of boiler is inferior to the other class of water-tube boiler, but much superior to the Scotch boiler.

Summing up, we may say that the Scotch boiler working at 250 lbs. pressure would burn the fuel well and utilize the heat satisfactorily, it would contain plenty of water to allow the irregularity in the feed, it would be not quite so accessible as the lower pressure boilers of the same type, and would have the same defects as to repairs of the internals. The danger from the presence of grease would certainly not be less, and the circulation would not be better. Extra care would be needed in raising and letting down steam to avoid straining from unequal temperature. Finally, the cost of construction would be more than that of the lower pressure boiler, and the space occupied only very little less.

The water-tube boilers of the Thornycroft, Yarrow, Normand, etc., type would burn the fuel well, but would not utilize the heat satisfactorily; they would have very little water to allow for irregularities in the feed, they would be very accessible for cleaning, and convenient for repairs. The circulation would be good, and there would be no danger of straining or leakage through unequal expansion. Finally, the cost of construction would be vastly less than that of the Scotch boiler and the space occupied considerably less.

The water-tube boilers of the Belleville, Babcock & Wilcox, etc., type would not burn the fuel well, but would utilize the heat satisfactorily; they would have sufficient water in them to allow for irregularity of feed, would be fairly accessible for cleaning, and convenient for repairs. If not pressed the circulation would be good, and there would be no danger of straining when raising steam or from unequal expansion. Finally, the cost of construction and the space occupied would be considerably less than that of the Scotch boiler.

There are up to the present, very few published trials of water-tube boilers on which any reliance can be placed, as the majority of them have been carried out by measuring the feed-water pumped into the boiler, but how much of this has been turned into steam is not known. The coal consumption trials of H. M. S. Sharpshooter and H. M. S. Powerful give the combined efficiency of the engines and boilers, which is very satisfactory compared with similar trials of the Scotch boiler, but how much this good result depends upon the higher boiler pressure and how much on the boiler itself is not known.

We can now pass on to discuss questions as to the best design for an engine suitable for 250 lbs. working pressure. The first question which arises is, into how many stages should the expansion be divided? When the triple expansion engine was first introduced, and effected a saving of 25 per cent in the coal consumption, its main source of economy was attributed to the use of three stages in the expansion, giving a small temperature range in each individual cylinder. This theory has of late years been to some extent discredited. The only method of getting at the truth would be to carry out a scientific experiment with engines indicating about the same power, with the same boiler pressure and number of expansions, one with two cylinders and two-stage expansion, and the other with three cylinders and three-stage expansion. No amount of theorizing will lead to any reliable conclusion, and Prof. Weighton's experiments on this subject will be awaited with interest.

As pointed out in the beginning of this paper, the economy due to raising the boiler pressure from 80 lbs. to 150 lbs. is theoretically about 23 per cent. As the maximum economy claimed by the triple expansion engine over the compound is not more than 25 per cent, there is no need to call in the three-stage expansion to account for the economy. The total temperature range for steam of 80 lbs. boiler pressure is 171 deg. F.; this, divided into equal stages, gives a range of 85.5 deg. F. for each cylinder. The total temperature range for 150 lbs. boiler pressure is 213 deg. F.; this, divided into three equal stages, gives a range of 71 deg. F. in each cylinder. That is to say, there is only a difference of 14 deg. F., under the most favorable conditions, between the temperature range of the compound and the triple expansion. Hence, in default of experiments on temperature range, we need not tie ourselves down to multiple expansion stages on account of steam economy.

The next question is that of number of cranks. The three-crank engine has now almost displaced the two-crank engine, on account of its more equable turning and balance, and four-crank engines are now coming into favor. The four cranks offer great facility for balancing the moving parts, and should, therefore, be adopted for a high number of revolutions, and where absence of vibration is of importance. They will, however, occupy more space fore and aft, thus necessitating a longer engine room, unless special means are taken to make the engine short.

The next point is the arrangement of cylinders. In the first place, tandem cylinders should only be used in cases of absolute necessity, owing to the inconvenience of overhauling the lower cylinder. Then, with three cranks, we may have two arrangements of cylinders, viz., (1) one high pressure and two low pressure; (2) one high pressure, one intermediate, and one low pressure. With four cranks three arrangements are possible, viz., (1) two high pressure and two low pressure; (2) one high pressure, one intermediate, and two low pressure; and (3) one high pressure, one first intermediate, one second intermediate, and one low pressure.

The most important qualifications for economy of design and working are:

First, the initial loads in each cylinder should be equal. Second, the cut-offs should be as late as possible, and practically equal in each cylinder, and so arranged that when working at the maximum voyage power the valve gear will be operating at its maximum efficiency. Third, the "drop" between the cylinders should be as small as possible consistent with economy of size of cylinders.

It is important to design engines with equal initial loads. It is invariably the practice to make the connecting rods, piston rods, crank shaft, anl main bearings in duplicate for each engine. Hence, if the initial loads are unequal, these parts must be designed for the maximum initial load. Speaking generally, the weight of the moving parts is proportional to the initial load and a function of the stroke, so that if a four-cylinder engine is designed with unequal loads, and the maximum is, say 10 per cent. greater than it would be with equal loads, then the weight of the moving parts of all four engines would be 10 per cent. greater than necessarv. The weight of the frame work of the engine is also affected by the initial loads; in fact, the total weight of engines of the same type should vary directly as the sum of the initial loads and some power of the stroke. It is also an advantage to have the cuts-off in each cylinder as nearly equal as possible. With the link motion there is a particular point of cut-off where the maximum efficiency is attained—that is to say, where the mean speed of steam during the admission is a maximum with a given value of travel. It will be seen that the later the cut-off the better the result, and that the efficiency falls off rapidly for cuts-off at less than 50 per cent. The cut-off in the high pressure cylinder should not be much less than 50 per cent. when linked up, as the later the cut-off the less is the proportionate loss from clearance, and an earlier cut-off than this in the other cylinders would mean a large increase of admission speed in the very cylinders where it is most difficult to get sufficient steam opening.

The best conditions as regards "drop" will be obtained if there is no drop, or a drop of a few pounds at the minimum voyage power (i. e., ship in ballast), which will give a reasonable drop for the loaded ship horse power.

Although, as pointed out above, we need not tie ourselves to multiple-expansion stages on account of any expected economy due to lessened temperature range, yet the use of more than one stage has the important effect of diminishing the sum total of the initial load, and, generally speaking, the more stages we use the less will be the total loss from drop.

Taking a cylinder 49 in. in diameter, with 4 lb. back pressure and 250 lb. initial pressure in the cylinder, the total initial load would be 463,700 lb. If, however, the expansion were divided into two stages, the total initial load would be, with cylinders 15 1-2 in. by 49 in., the combined initial load would equal 85,200 lb., a reduction of no less than 80 per cent on the single-stage load. Of course the actual reduction in weight would not be so much as this, as the weight of one engine with a certain initial load will be less than the combined weight of two engines with the same combined initial load.

For two-stage three-crank engines, with cylinders 15 1-2 in. by 34 1-2 in. by 34 1-2 in., the combined initial loads = 115,415 lb., an increase of 35 per cent over the combined loads for the two-stage two-cylinder arrangement. For the three stage three-cylinder engine, with cylinders 15 1-2 by 26 1-2 in. by 49 in., the combined initial load = 95,700 lb., rather more than with the two-stage two-cylinder arangement.

For the three-stage four-cylinder arrangement, with cylinder 15 1-2 in. by 25 1-2 in. by 34 1-2 in. by 34 1-2 in., the combined intial load = 118,900 lb., an increase of 24 per cent over the three-stage three-cylinder arrangement.

For the four-stage four-cylinder arrangement, with cylinders 15 1-2 in. by 22 in. by 32 in. by 49 in. the combined initial load = 98,500 lb., a slight increase over the three-cylinder three-stage arrangement.

The table below shows the above figures put together:

Arrangement.	Cylinders.	Combined initial load.
Single-stage.....	49	463,700
Two-stage, 2 cylinders...	$15\frac{1}{2} \times 49$	85,200
" 3 " ...	$15\frac{1}{2} \times 34\frac{1}{2} \times 34\frac{1}{2}$	115,400
Three-stage, 3 cylinders.	$15\frac{1}{2} \times 26\frac{1}{2} \times 49$	95,700
" 4 " .	$15\frac{1}{2} \times 25\frac{1}{2} \times 34\frac{1}{2} \times 34\frac{1}{2}$	118,900
Four-stage, 4 cylinders..	$15\frac{1}{2} \times 22 \times 32 \times 49$	98,500

Boiler pressure, 250 lb.
Total expansions, 18½.
Equal initial load in each cylinder.
Cut-off in first cylinder, 54 per cent.

From which it will be seen that the worst results after the single-stage arrangement is attained by the divided low-pressure cylinder arrangements.

The following table shows the cuts-off in each cylinder to give equal initial loads with the above cylinder ratios:

Two-stage, 2 cylinders, or two-stage, 4 cylinders.	Cylinders.....	$15\frac{1}{2}$	49			
	Cuts-off, per cent..	54	42			
Two-stage, 3 cylinders,	Cylinders.....	$15\frac{1}{2}$	$34\frac{1}{2}$	$34\frac{1}{2}$		
	Cuts-off, per cent..	54	27	27		
Three " 3 "	Cylinders.....	$15\frac{1}{2}$	$26\frac{1}{2}$	49		
	Cuts-off, per cent..	54	54	54		
Three " 4 "	Cylinders.....	$15\frac{1}{2}$	$25\frac{1}{2}$	$34\frac{1}{2}$	$34\frac{1}{2}$	
	Cuts-off, per cent..	54	51	33	33	
Four " 4 "	Cylinders.....	$15\frac{1}{2}$	22	32	49	
	Cuts-off, per cent..	54	55	55	57	

From which it will be seen that the greatest uniformity of cut-off is attained by the three-stage three-cylinder, and the four-stage four-cylinder, and that the cuts-off in the divided low pressure cylinders are impossibly early.

The two-stage two- or four- cylinder arrangement may be arranged to have equal initial loads, and equal cuts-off by increasing the high pressure cylinder as shown below:

Two-stage, 2 cylinders, or two-stage, 4 cylinders.	Cylinders.....	$20\frac{1}{2}$	49
	Cuts-off, per cent.....	30	30

Combined initial load = 138,700.

With the two-stage three-cylinder and the

three-stage four-cylinder it is impossible to get equal initial loads and equal cuts-off unless the terminal pressure in some of the cylinders is below the back pressure.

The latter arrangement of two-stage two or four-cylinder would be suitable if equal loads and equal cuts-off were desired, and if the total expansions were, say, 10 1-2 instead of 18 1-2, thus making the cuts-off in each cylinder 54 per cent. Of course this arrangement entails an addition of 60 per cent. to the total initial load of the unequal cut-off arrangement. It will be interesting at this point to give the actual initial loads of some three-stage four-cylinder engines. These below are for H. M. cruiser Powerful, the particulars being taken from the published indicator cards taken on her trial trip.

H. M. S. POWERFUL.

High pressure	= 213,000 lb
Intermediate pressure	= 219,300 lb
Low pressure	= 104,300 lb

It will be noticed that the initial load on each low-pressure cylinder is less than one-half the load on the high-pressure and the intermediate-pressure cylinder. If the initial loads had been equal the load on each cylinder would have been 177,000 lbs. The load on the intermediate-pressure is, however, actually 219,300 lbs., and as the rods, etc., are of the same scantlings throughout, the weight of the moving parts and the surface of the principal bearings are approximately 25 per cent greater than would have been necessary with equal initial loads. The author is not aware of the reason for this. Probably the equal initial loads would have entailed a too early cut-off in the low-pressure cylinders, and consequent insufficiency of steam opening; or perhaps the size fixed upon for the intermediate cylinder would, with equal initial loads, have brought the terminal pressure of that cylinder below the back pressure; or it may have been deemed expedient to keep the pressure in the low-pressure steam-chest as low as possible to minimize the load on the slide valves.

We can now consider the question of "drop" between the cylinders. To attempt to determine the theoretical loss due to drop would involve a very complicated calculation. In the first place, when steam expands without doing external work, it becomes superheated, or, if it contains moisture, some of the latter will be evaporated; and in the second place a given drop at a low pressure will not cause so much loss as the same drop at a higher pressure, as high pressure steam is more valuable to us than low pressure steam. Hence, to simplify matters, the drop in the following remarks has been calculated as the area or areas under a $\frac{1}{9}^{0}$ curve drawn from the terminal pressure in the cylinder to the back-pressure line of the cylinder. The proportion which this area bears to the area under a $\frac{1}{9}^{0}$ curve with the same initial pressure, back pressure, and expansions, as the cases under consideration, have been called the "percentage of loss due to drop."

The following table shows the comparative loss from drop of the different types of engine we have been considering:

Type.	Initial loads and cut off.	Cylinders.	Drop Lbs.	Loss due to drop per cent.
Two stage 2 or 4 cylinders.	Equal loads / Unequal cuts-off.	15½ × 49	81	15
Two-stage 2 or 4 cylinders.	Equal loads / Equal cuts-off.	20½ × 49	25	2
Two stage 3 cylinders.	Equal loads / Unequal cuts-off.	15½ × 34½ × 34½	75	10
Three-stage 3 cylinders.	Equal loads / Equal cuts-off.	15½ × 26½ × 49	42 / 12	4½
Three-stage 4 cylinders.	Equal loads / Unequal cuts-off.	15½ × 25½ × 34½ × 34½	21 / 1	1
Four-stage 4 cylinders.	Equal loads / Equal cuts-off.	15½ × 22 × 32 × 49	1 / 1 / 2	½

From which it will be seen that the best result is attained by the four-stage cylinder type, and the worst by the two-stage two-or four-cylinder type, with equal initial loads and unequal cuts-off.

Award of Contracts for Torpedo Craft.

Awards of the contracts for the new torpedo boats and torpedo boat destroyers have been made by the Navy Department as follows:

Bath Iron Works, Bath, Me.—Two torpedo boats, at $161,000 each, provided the company agrees to certain changes in plans.

Columbian Iron Works and Dry Dock Company, Baltimore, Md.—One torpedo boat, on Department plans, at $168,000.

Gas Engine and Power Company, Morris Heights, New York.—One destroyer, the exact price yet to be determined, as this company bid on a destroyer and a torpedo boat jointly. One torpedo boat, exact amount of bid to be determined later.

Harlan & Hollingsworth Company, Wilmington, Del.—Two destroyers on bidder's plans, at $291,000 each.

Lawley, George & Sons, South Boston.—Two torpedo boats, on Department plans, at $159, 400 each.

Maryland Steel Company, Sparrows Point, Md.—Three destroyers, on bidder's plans, at $286,000 each.

Neafie & Levy, Philadelphia, Pa.—Three destroyers on Department plans, at $283,000 each.

Nixon, Lewis, Elizabethport, N. J.—One torpedo boat on bidder's plans, at $161,000; two torpedo boats, on bidder's plans, at $165,000 each.

Trigg, William R., Richmond, Va.—Two destroyers on Department plans, at $260,000 each; three torpedo boats on Department plans, $129,750 each.

Union Iron Works, San Francisco, Cal.—Three destroyers on Department plans, at $285,000 each.

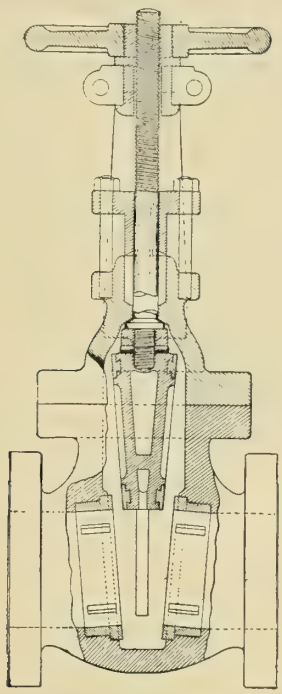
Wellington, Frank O., & Co, Fore River Engine Company, Weymouth, Mass.—Two destroyers on bidder's plans, at $281,000 each.

In the case of William R. Trigg, of Richmond, Va., the award will necessitate the establishment of a shipyard at that point within the stipulated time—three months. Arrangements are now in progress, we understand, for the purchase of a site formerly used as a foundry.

IMPROVED APPARATUS.

Improved High Pressure Gate Valve.

This drawing herewith shows an improved gate valve manufactured by the Coldwell, Wilcox Co., of Newburgh, N. Y., and which is especially adapted for extreme high pressures. It will be noticed that the body of the valve is of the oval form, all sharp corners and ribs being done away with, and the metal is so proportioned that no unequal shrinkage strains occur. The seats of the

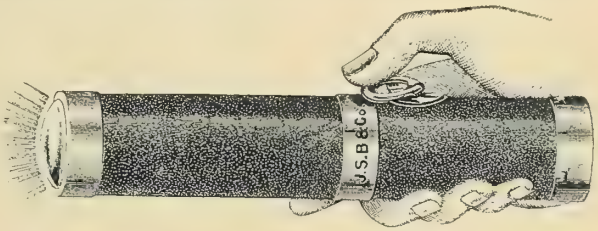


HIGH-PRESSURE GATE VALVE.

valve are of special hard bronze, made heavy, and with a long deep thread on the smaller end of the seat. The rim or larger part of the seat is turned true, and fitted to the recess turned out in the shell. The seat is screwed in and shoulders on this recess making a tight and stable joint, and being made heavy there is no danger of springing. The seats are parallel, and are screwed in to suit the angle of the wedge or gate. The gate of these valves is a heavy double shell casting, fitted with bronze bearing rings in all valves from 8 in. and upwards; under 8 in. the wedge or gate proper is entirely of bronze. The stem is made of bronze, fastened in the wedge so that the wedge is free to move and seat itself. The stem has a projection cast on above where it enters the hub of the wedge, and this turned and ground true into the seat formed in the top of the bonnet, thus enabling these valves to be packed when full open, and steam on. The stem has a thread cut on its top end to engage in a solid bronze nut, and this nut is keyed to the hand wheel, or to gearing when gears are used. The nut also extends below the portion where the thread is cut, and is fitted into a yoke cast in two pieces; the nut having a shoulder top and bottom to keep it stationary, the stem rising or lowering as the valve is opened or closed. The bronze stuffing box is made very heavy and long, and a long recess is provided for packing. About three hundred of these valves are at present in constant use, and are said by the manufacturers to be giving entire satisfaction.

Safety Pocket Electric Light.

A safety pocket light for the use of engineers and deck officers of steamships recently put on the market is shown in the accompanying illustration. It can be instantaneously lighted in any place on shipboard, on deck in a gale or in an oil tank, without fear of its going out or causing an explosion. As it is of portable size and weighs little more than one pound, it can be comfortably carried in the pocket. It is guaranteed by the makers to give approximately 6,000



POCKET ELECTRIC LIGHT.

to 8,000 "lights" before the battery requires renewal. Extra batteries are supplied and can easily be inserted in place. The light contains no mechanism which can get out of order, nor chemicals which might leak out. The manufacturers are James S. Barron & Co., 24 Hudson St., New York.

Traveling Ramps for Unloading Vessels.

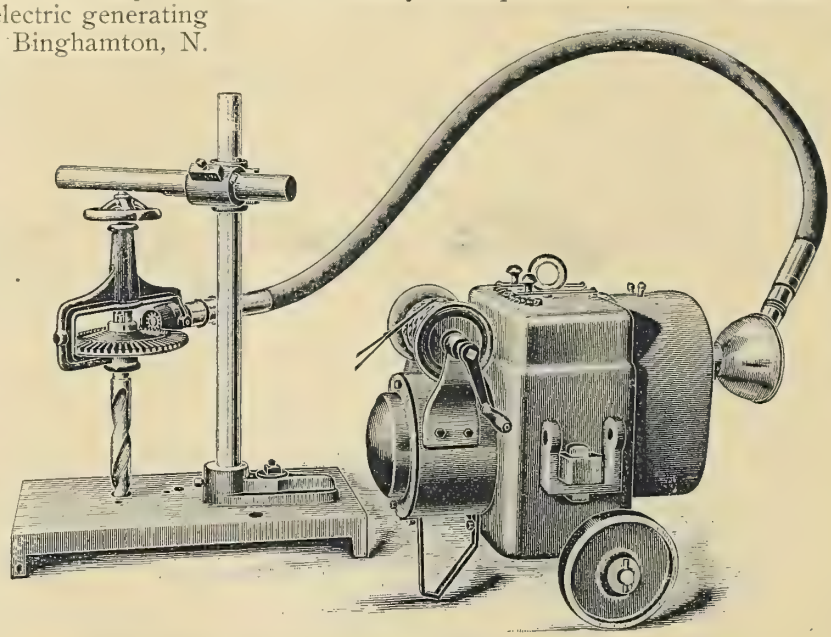
In the illustration, page 28, there is shown a device for facilitating the loading and unloading of vessels that is being introduced by the Link Belt Engineering Co. It is styled a Traveling Ramp, and in form is a development of the familiar gangplank. The apparatus is pivoted at its inboard end so that the counterweighted outboard end may be readily raised or lowered to meet the varying heights of loading ports of different vessels. It is composed of a moving section, the direction of travel of which may be reversed to carry either to or from the vessel, and a stationary gangway, upon which the freight handlers return to the warehouse or to the vessel with their empty trucks. The machine is guaranteed to increase the capacity of any steamship pier where it is used, by making it possible to load or unload vessels more rapidly than by the present methods, and it is claimed for it that it will reduce the number of men necessary and will lessen fatigue and so increase the capacity of the men who use it. The metal-covered slats composing the moving apron form recesses, between

which it will be noticed the wheels of the trucks rest, and these recesses also serve to hold in place barrels, boxes or other packages which it is unnecessary to place on trucks. A modified form of the machine dispenses with the stationary gangway, it being replaced by an additional moving section, traveling in a direction opposite to that of the other half of the machine. This arrangement makes it possible to load and unload freight simultaneously, but if only one operation is to be done at a time and it is advisable to carry the freight on trucks, these trucks need not be attended on the ramp, men stationed at the discharging end receiving and unloading them and returning them on the apron traveling toward the freight to be loaded or unloaded. Traveling ramps have been installed at the piers of the Boston Steampship Co., Boston; the Northern Steamship Co., Buffalo, and the Southern Pacific Railway Co., New Orleans. The address of the Link Belt Engineering Co. is Nicetown, Philadelphia, Pa.

TRAVELING RAMP IN OPERATION.

Flexible Shaft and Ironclad Electric Motor.

The seriousness of an accident at sea is greatly enhanced by lack of adequate tools to expeditiously make repairs. Under no other conditions is time of more vital importance. Yet of necessity, this work is largely done through the slow medium of hand tools. It would seem that under these circumstances a portable tool, simple, compact and easily transported to any distance from the souce of power, one that will bore, drill, tap or ream as rapidly as the work can be done in a well equipped machine shop, should become almost a necessity on board any seagoing vessel provided with an electric generating plant. The Stow Mfg. Co., of Binghamton, N. Y., believe that in their combination of Stow flexible shaft and ironclad electric motor will be found an appliance meeting all these requirements. The Stow flexible shaft has been so long on the market and in such general use, as to require no detailed description, but its introduction into the maritime field has only recently been made possible by the general use of electricity on shipboard. The ironclad motor is designed with special reference to use with the flexible shaft, is very simple in construction, practically dust and waterproof and unbreakable, thus peculiarly fitting it for the rough usage that a portable motor must of necessity meet at sea. The fact that by simply changing the oil cups it will run equally well in any position permits it to be used in contracted spaces, which would otherwise be inaccessible. By simply connecting the insulated wire on the reel to the power current the plant is ready for work, and can be easily transported wherever needed.



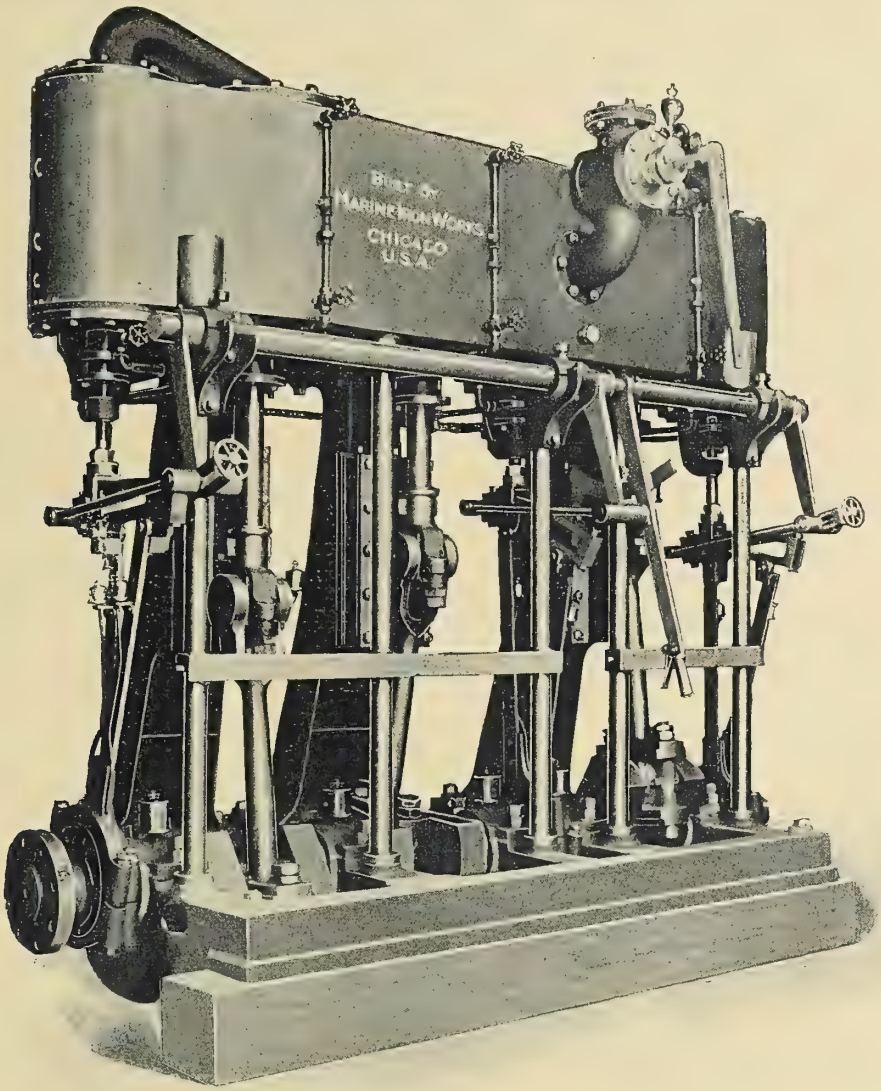
STOW PORTABLE DRILLING APPARATUS FOR SHIP USE.

This apparatus has been in use for some time in U. S. Navy Yards and in large private

shipbuilding concerns giving satisfactory results. The general European agents are, Selig Sonnenthal & Co., London, England.

Triple Cylinder Compound Marine Engine.

Our illustration shows a type of three-cylinder compound engine recently designed by the Marine Iron Works, in which compactness and light weight combined with strength and durability have been specially sought. The cylinders and finished in the journals to 5 1-2 in. dia. The crank pins are 5 1-2 in. dia. and 6 3-4 in. long. Steel is also used for the crossheads, with adjustable bronze slippers. The back columns and bed plate are made of the material usually termed "semi-steel" (cast-iron with an admixture of steel scrap), and a specially hard mixture is used for the cylinder bodies. As shown, the engine has an open front with turned steel columns, so that all working parts can be readily got at when run-



MARINE IRON WORKS—THREE-CYLINDER COMPOUND ENGINE.

are 12 in. and 18 in. dia., and 14 in. stroke. The high pressure cylinder is placed between the two low pressure, and the cranks are set at 120 deg. apart. Double-ported balanced piston valves, fitted with expansion rings, are used on all three cylinders, and are driven by Stephenson link motion. Open-hearth steel is used for the crank shaft, which is slotted out from a solid forging ning. The general dimensions are: Width of bed plate, 52 in.; length of bed plate, 90 in.; height to top of cylinders, 87 in., and weight of engine ready for steam, 9,000 lbs. The finish, without being elaborate, is of the practical kind and consistent with an up-to-date high-grade marine engine. The Marine Iron Works are located at Chicago, Ill.

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NOW that mutual admiration has been exhausted on the practical results of the Santiago sea fight July 3 last, it is seasonable to make some inquiry into facts of scientific interest. Popular journals of every grade and degree have iterated and reiterated statements about the landing of the heaviest shells in the enemy's vessels and the unerring marksmanship of our gunners until Baron Munchausen has appeared a model of veracity by comparison. In other columns we give some facts of interest gathered from official sources which are a surprise even to the initiated. From these it appears that while the engagement lasted our ships fired nearly 9,000 shots. A careful survey of the wrecked Spanish cruisers by a thoroughly competent board of our officers showed only 125 apparent hits. Therefore deducting the shots fired by the Gloucester at the torpedo boat destroyers Pluton and Furor (these boats could not be examined for hits) and allowing a liberal number of shots fired at these boats by our larger vessels the identified hits were less than two per cent. of the total discharges. Most singular, too, the examination did not disclose a single hit by any of our 13 in. guns in action. These results were obtained with the acknowledged good marksmanship of our gunners; what poor marksmen can do the Spanish have demonstrated.

PERIODICALLY when the loss of a liner by collision is reported the subject of bulkheads in steam vessels comes into prominence. It is one feature which, perhaps, has occasioned more thought than any other in hull construction. With some it has become a fetish to which blind obeisance is made, and they would honeycomb a vessel with partitions so that each man aboard would need a detail plan to get from one end of the ship to the other. The serious importance of the subject is well recognized however among those who design and build full powered vessels. In recent comment in the technical press there has been a good deal said about subdivision by longitudinal bulkheads with special emphasis on the supposed absolute safety which attends their use. A distinguished English contemporary cites the mishap to the City of Paris as showing the extreme usefulness of the fore and aft subdivision. Unless our memory is seriously at fault this accident was in no sense a test of the emergency efficiency of the longitudinal bulkhead. When the starboard engine went to pieces tearing away the sea connections, portions of the engine went through the longitudinal engine room bulkhead, so that the water rapidly filled both engine rooms. The engineers were driven up and the vessel rolled helplessly in the sea, with 2,600 tons of water in her engine compartments, until taken in tow and brought to Queenstown. There the sea connections on the starboard side and the bulkhead rents were plugged, the vessel pumped out and with her port engine alone she steamed to Liverpool. The longitudinal bulkhead, if permanently watertight, might prove a greater danger than safe guard in case of damage to the skin in the vicinity of the engines, for the filling up with water of one engine room would be accompanied by an inclination of the vessel to the same side. The results of a theoretical investigation into this phase of the subject are interesting. Taking a liner between 500 and 600 feet in length, the capacity of engine room compartments bounded by fore and aft and 'thwartship bulkheads was figured at lengths of 40, 60, 80, 100 and 120 feet, giving (roughly) weights of 800, 1,200, 1,600, 2,000 and 2,400 tons of water. Then presupposing a general steadiness of trim and a suitable stability curve of average or moderate amount the angles of heel produced by the inflow of water were found to be for the 40 ft.

compartment 16°, the 60 ft. 22°, the 80 ft. 25°, the 100 ft. 29° and the 120 ft. 33°. It will thus be seen that for even a moderate sized engine compartment in a twin-screw vessel, if tight, the corresponding degree of inclination would be very serious indeed, especially in rough water. The propeller of the engine in the undamaged compartment would be partially out of the water, the water level in the boilers would be very seriously disturbed and the difficulties of operation in the machinery department would be enormously increased. It is very likely too that such a permanent list of the vessel would in a liner cause a fearful panic. The longitudinal bulkhead is a good structural member if properly fitted, but it should not be without openings. We believe we are correct in saying that it is the practice now, in vessels so fitted, either to leave a permanent opening between the engine rooms or to have an opening fitted with a watertight door which is invariably kept open when the vessel is at sea. Should timely warning of an accident be given this door would be left open when all doors in the 'thwartship bulkheads would be clamped tight. Should the skin of the vessel be ruptured in either engine room both compartments would fill equally and so the only effect of the inrush of water would be to increase the displacement without seriously altering the trim or causing any heeling of the vessel. Doors in the cross bulkheads would isolate the engine compartments from the boiler rooms forward and the tunnels aft. Then the watertight door in the longitudinal bulkhead between the engine rooms would be closed, the water in the sound engine room blown out by the ejector and at the same time the water bottoms and bunkers on the same side filled with sufficient water to maintain the equilibrium of the vessel. How far this would be successful has not, we believe, been tried, and therein indeed is the chief difficulty about the whole question of bulkheads. There is little or no opportunity for experiment on a large scale. Disaster has been the only guide, and in many instances has not pointed the way toward perfection.

AN examination of the world's shipbuilding returns for 1897 compiled by Lloyd's Register of British and Foreign Shipping is pleasanter reading as history than it would have been as prophecy at the commencement of the year, so far as the United States are concerned. The figures show a tremendous falling off in the tonnage built here, a condition which is not shared to anything like the extent by any other country. This country has fallen from second place on the list, which it had held for two years, to third place, Germany moving up one step next to the premier position, occupied as a matter of course, by the United Kingdom. Returns for the last mentioned also show a decrease and this is true, too, of the Netherlands, the other maritime nations on the contrary showing increases throughout. Taking account of all vessels over 100 tons and reckoning the gross register of steamships and net register of sailing vessels the output of the United States for 1897 was 72,581 tons, or 102,280 tons less than 1896, and 24,758 tons less than 1895. Germany turned out 153,688 tons in 1897, an increase of 73,210 tons over the figures for 1896. This increase, it will be observed, was a greater tonnage than the entire output of this country during the twelve months. Returns for the United Kingdom show a total of 907,711 tons as compared with the figures for 1896, which footed up 1,121,505. This falling off can be largely accounted for by the prolonged engineers' strike, which greatly retarded the completion of vessels in British yards and probably transferred many orders to Continental builders. In France there was a large increase in new tonnage, the totals raising from 33,546 tons in 1896 to 50,940 tons in 1897. The total for all countries for 1897 was 1,286,503 tons, a falling off from the previous year, in which 1,478,375 tons were constructed, but a slight increase over the total for 1895, during which the new tonnage amounted to 1,211,615 tons. The number of vessels for all countries built during 1897 was 891, and during 1896 977. Of the former 725 were steam vessels and 166 sailing vessels. There was a falling off in the number and tonnage of sailing vessels, which, indeed, has been steadily going on for several years. In the United States the total number of steam vessels built in 1897 was 33, of 36,975 tons, considerably less than half the number during the preceding year, and the number of sailing vessels was 29, of 35,606 tons, as against 46 of 54,603 tons in 1896. Of this sail tonnage, nine were steel ships of a total of 23,079 tons, and twenty were wooden vessels of a total of 12,527 tons. The total tonnage owned by the United States was 2,448,677 tons.

EDUCATIONAL.

CALCULATIONS FOR ENGINEERS—AN AID TO CANDIDATES FOR MARINE PAPERS—I.

BY DR. WILLIAM FREDERICK DURAND.

§1. COMMON FRACTIONS.[1]

[1] One of the principal duties of the engineer is to measure things. Thus he may be called on to find the length of a section of shafting, the diameter of a piston-rod, the weight of a screw-propeller, the volume of an oil-tank, or the capacity of a coal-bunker. Measuring consists in nothing more or less than comparing the quantity to be measured with another quantity of the same kind, and so finding how many times the latter is contained in the former. Thus in measuring a length of shaft with a foot rule we really compare the length of the shaft with the length of the rule, and so find, for example, that the shaft is 14 feet in length; that is, that it is 14 times as long as the rule, or that its length contains the length of the rule 14 times. All these are simply different ways of saying the same thing. Now the foot rule or the foot in such an operation is called the *unit*.

Again, in measuring the weight, say, of a screw propeller, the operation really amounts to making a comparison between the weight of the propeller and the standard weight called the *pound*. Here likewise the pound is the *unit*.

It is easily seen that the unit must be the same kind of quantity as the thing to be measured, else no direct comparison can be made between them: thus a unit length to measure length, a unit area to measure surface, a unit volume to measure volume, a unit weight to measure weight, etc.

Now if we wish to measure the length of our section of shafting with some degree of accuracy we shall probably find that it is not an exact number of feet. We may perhaps find its length between 14 and 15 feet. We then proceed to measure the inches and find, let us say, 14 feet 5 inches, with an additional length less than one inch. With still greater accuracy we might go on and find perhaps 14 feet $5\frac{7}{16}$" as the length correct to a sixteenth. Now let us set down this length as follows: 14 feet, 5 inches, 7 sixteenths inch. It is easily seen that if the *foot* is a unit of length so is the *inch*, and so is the *sixteenth-inch*. Here then in measuring a piece of shaft we have used three kinds of units, the foot for most of the length, the inch for most of the remainder, and the sixteenth-inch for the little that finally remained. We know very well that the sixteenth-inch is obtained by simply dividing the inch up into sixteen equal parts and taking one of them, while the inch is gotten similarly by dividing the foot into twelve equal parts and taking one of them. It thus appears that these units are all related together; the sixteenth comes from the inch, and the inch from the foot.

A unit which is thus obtained by taking one of the equal parts into which a larger or principal unit may be divided is often called a *fractional unit*. Thus the inch is a fractional unit relative to the foot; while the half-inch, quarter-inch, eighth-inch, etc., are all fractional units relative to the inch. In general we can always suppose any given quantity considered as a principal unit, to be divided up into any number of equal parts, as 3, 8, 16, 100, 144, 2196, etc., and we can then take one of these parts as a fractional unit and with it proceed to measure any given amount of the same kind of quantity.

[1] The reader is supposed to be somewhat familiar with the general subject of fractions as presented in the elementary text books of arithmetic. The present section is not intended as a complete discussion of the subject, but rather as a short compendium of the more important operations, based on a point of view somewhat different from that given in the usual text books.

Now when we measure quantities with fractional units the result is known as a *fraction*. Thus the fraction five-twelfths ($\frac{5}{12}$) is the measure of a quantity in terms of the unit *one-twelfth*, just as five inches is the measure of a quantity in terms of the unit *one inch*, and in each case the measure is simply five such units. Or to put the same thing the other way around, if we measure a quantity in terms of a fractional unit such as one-twelfth ($\frac{1}{12}$), for example, and find that the measure is five such units, then we write the result $\frac{5}{12}$, and such an expression is known as a *fraction*. For the engineer it is always most natural to bear in mind this idea of a fraction, and to consider that it is simply the measure of a certain quantity in terms of a fractional unit.

When we are handling fractions simply for exercise in arithmetic we do not always stop to ask what kind of a unit it is, or what kind of a quantity we are dealing with. For an exercise in arithmetic it makes no difference, but the engineer in actual problems always knows what he is dealing with, and what kind of a unit is meant.

In the usual way of writing fractions, as $\frac{5}{12}$, $\frac{7}{16}$, $\frac{3}{10}$, $\frac{23}{144}$, etc., the number below the line is called the *denominator* and shows into how many equal parts the larger or principal unit is divided in order to furnish the smaller or fractional unit. The denominator thus shows the relation of the fractional unit to the principal unit. The number above the line is called the *numerator* and shows how many of these fractional units are used to measure the quantity in question.

Proper Fraction. In a proper fraction such as $\frac{3}{4}$ the numerator is less than the denominator, showing that the quantity measured is less than the principal unit.

Improper Fraction. In an improper fraction as $\frac{17}{12}$, the numerator is greater than the denominator, showing that the quantity measured is greater than the principal unit.

Mixed Number, or Whole Number and Fraction. Such an expression means that the quantity is measured in terms of two units. Thus $7\frac{5}{12}$ means seven principal units and five fractional units, the latter unit being one twelfth the former. This is exactly similar to the measurement of length in feet and inches, or weight in pounds and ounces. Thus if the foot is the principal unit, $7\frac{5}{12}$ means simply 7 feet and 5 inches, or if the pound is the principal unit, $8\frac{9}{16}$ means 8 pounds and 9 ounces. We may also recall the illustration used near the beginning of this section where three units were used to find the length of a piece of shafting.

---

[2] Reduction of a Mixed Number to an Improper Fraction. This means simply the reduction of the measure all to terms of the smaller or fractional unit, just as we may reduce a measure in feet and inches all to inches. Thus to reduce $7\frac{5}{12}$ to an improper fraction we see that in each of the seven principal units there are 12 fractional units, and hence 7×12 or 84 such units in the whole number. In addition, there are 5 more fractional units, and therefore $84 + 5$ or 89 in all. The reduced value is therefore $\frac{89}{12}$. In a similar way if the principal unit were the foot we should reduce 7 feet and 5 inches to inches by multiplying the 7 by 12 and adding in the 5, giving 89 inches similar to the 89 twelfths ($\frac{89}{12}$) above. We have therefore the following:

Rule—Multiply the whole number by the denominator and add in the numerator. The result is the numerator of the improper fraction, and the denominator is the same as before.

Problems—Reduce to improper fractions the following:

$$2\frac{5}{6},\ 8\frac{4}{7},\ 12\frac{7}{16},\ 8\frac{11}{12},\ 12\frac{13}{16},\ 17\frac{23}{45},\ 264\frac{123}{144}.$$

---

[3] Reduction of an Improper Fraction to a Mixed Number. To reduce an improper fraction

such as $\frac{31}{12}$ to a mixed number we must evidently find first how many principal units there are. Since 12 fractional units make 1 principal unit, it is evident that the number of principal units will be found by dividing 31 by 12. The quotient will then give the number of principal units and the remainder will give the remaining number of fractional units. Thus $31 \div 12 = 2$ principal units and 7 remainder, or 7 fractional units over; or $\frac{31}{12} = 2\frac{7}{12}$. Hence the following:

Rule—To reduce an improper fraction to a mixed number, divide the denominator into the numerator and the quotient will be the whole number, while the remainder will be the numerator of the fraction, and the denominator will be as before.

Problems—Reduce to mixed numbers the following:

$$\frac{76}{13}, \frac{198}{144}, \frac{289}{101}, \frac{56}{21}, \frac{95}{76}, \frac{143}{117}, \frac{264}{84}, \frac{764}{19}.$$

[4] Reduction of Fractions without Change of Value. If we change the size of a unit of measure we shall change the measure of the quantity in like proportion. Thus, for example, the number measuring the diameter of a bolt in sixteenths as a unit will be twice as great as if measured in eighths as a unit. Thus $\frac{6}{16}$ and $\frac{3}{8}$ represent the same quantity, one measure being in sixteenths and the other in eighths. It follows that we can multiply or divide both terms of a fraction (the numerator and denominator) by the same number without changing its value. Thus $\frac{2}{3}, \frac{4}{6}, \frac{6}{9}, \frac{10}{15}, \frac{14}{21}, \frac{16}{24}, \frac{20}{30}, \frac{42}{63}$, etc., all represent the same quantity measured in terms of different units, and it is seen that the $\frac{2}{3}$ may be changed into any of the other forms by multiplying both numerator and denominator by the same number, and similarly any of these latter forms may be reduced back to the $\frac{2}{3}$ by dividing both numerator and denominator by the same number.

Thus $\frac{2 \times 7}{3 \times 7} = \frac{14}{21}$ and $\frac{16 \div 8}{24 \div 8} = \frac{2}{3}$.

It may often be convenient to reduce a fraction to another of equal value but having some particular or specified denominator. To this end we divide the denominator desired by the denominator of the fraction, and multiply both terms of the fraction by the quotient. That is, we must multiply both numerator and denominator by some number which will produce the desired denominator. Thus to reduce $\frac{2}{3}$ to a fraction whose denominator is 42 we divide 42 by 3 and find 14. We then multiply both terms of $\frac{2}{3}$ by 14 and thus find $\frac{28}{42}$ as the fraction desired.

Lowest Terms. A fraction is said to be reduced to its lowest terms when there is no whole number which will divide both numerator and denominator without a remainder. Thus in the foregoing string of fractions $\frac{2}{3}$ is in its lowest terms while none of the others is. To reduce a fraction to its lowest terms we seek a factor which will divide both numerator and denominator and divide, continuing the operation until no further reduction can be made.

Example—Reduce $\frac{18}{24}$ to its lowest terms. We may first see that 2 will divide both terms without remainder. Dividing we have $\frac{9}{12}$ as a reduced value. We then see that 3 will again divide both terms, and thus find $\frac{3}{4}$ as the lowest reduction. We may also note at first that 6 will evenly divide both terms, and thus find $\frac{3}{4}$ by a single operation.

Problems—Reduce the following to their lowest terms:

$$\frac{72}{216}, \frac{350}{770}, \frac{116}{48}, \frac{864}{1728}, \frac{42}{81}, \frac{231}{1331}, \frac{56}{44}, \frac{72}{24}, \frac{19}{57}.$$

Addition, Subtraction, and Multiplication of Common Fractions.

Considering fractions as representing the measures of various quantities, we may be called upon to perform upon them the four fundamental operations of mathematics—addition, subtraction, multiplication, and division. These we will briefly consider in order.

[5] Addition of Fractions. We cannot combine directly $\frac{2}{3}$ and $\frac{3}{4}$ into a single quantity any more than we can 2 feet and 3 inches, or 6 miles and 8 feet. The reason is that the units are not the same in the two quantities which we seek to combine, and before the combination can be effected we must reduce the measures to the same unit in each. To this end we take advantage of the operations explained in [4] and reduce the fractions to a common denominator or common unit of measure. We naturally seek for this denominator as small a number as possible, and hence proceed according to the common rule for finding the L. C. M. (*least common multiple*) of the denominators. We then proceed to express the various fractions all with this L. C. M. as the common denominator by the method explained in [4]. We may then add the numerators and reduce the result as may be possible.

This is the foundation for the usual rule which may be expressed as follows:

Rule. (1) Find the L. C. M.[2] of all the denominators for a new denominator.

(2) Divide each denominator into this L. C. M. and multiply the corresponding numerator by the quotient for a new numerator.

(3) Add the new numerators thus found, and the result is the numerator of the sum desired.

(4) Write this numerator over the L. C. M. or common denominator, and reduce to the lowest terms.

Examples. Add $\frac{5}{18}$ and $\frac{1}{4}$.

The L. C. M. of 18 and 4 is 36. We then have:

$$\frac{5}{18} + \frac{1}{4} = \frac{10 + 9}{36} = \frac{19}{36}.$$

Add $\frac{3}{16}$, $\frac{2}{3}$ and $\frac{5}{6}$.

The L. C. M. of 16, 3 and 6 is 48. We then have:

$$\frac{3}{16} + \frac{2}{3} + \frac{5}{6} = \frac{9 + 32 + 40}{48} = \frac{81}{48} = \text{by reduction } \frac{27}{16}.$$

If there are but two fractions to be added and both have 1 for a numerator, a short rule for their addition is as follows: Write the sum of the denominators over their product and the fraction thus formed is the sum desired.

Thus $\frac{1}{8} + \frac{1}{6} = \frac{14}{48} = \frac{7}{24}$.

[6] Subtraction of Fractions. This operation requires reduction to the same unit of measure in the same way and for the same reason as in the case of addition. We have hence the usual rule, which may be expressed as follows:

(1) Find the L. C. M. of the two denominators for a new denominator.

(2) Divide each denominator into this L. C. M. and multiply the corresponding numerator by the quotient for a new numerator.

(3) Subtract the new numerators, and the result will be the numerator of the difference desired.

[2] For convenience in connection with these operations, we give as follows the rule for finding the least common multiple of a series of numbers—*i. e.*, the smallest number which will contain each without a remainder.

Rule—Write the numbers in a line (as (1) below), and select any number (as 4 in this case) which will divide at least two of them without remainder. Divide and set down the quotients underneath, except where the division would not be exact, in which case bring down again the number itself (as shown in line (2) below). Proceed with this line the same as with the first, and so continue until no two numbers have a common divisor. Then multiply together all the numbers remaining on the last line, together with all the divisors, and the product will give the least common multiple desired.

Example—Find the L. C. M. of 8, 36, 20, 6.

Operation:

4)	8	36	20	6....Line (1)
3)	2	9	5	6....Line (2)
2)	2	3	5	2....Line (3)
	1	3	5	1....Line (4)

L. C. M. $= 4 \times 3 \times 2 \times 3 \times 5 = 360$.—Ans.

(4) Write this numerator over the L. C. M. or common denominator, and reduce to lowest terms. Thus to subtract $\frac{1}{4}$ from $\frac{7}{18}$ we have as follows:

$$\frac{7}{18} - \frac{1}{4} = \frac{14 - 9}{36} = \frac{5}{36}.$$

If both numerators are 1 a short rule for the subtraction of the fractions is as follows: Write the difference of the denominators over their product and the fraction thus formed is the difference desired. Thus $\frac{1}{2} - \frac{1}{5} = \frac{3}{10}$.

Problems in Addition and Subtraction of Fractions. Perform the following additions:

$(\frac{1}{2} + \frac{1}{3} + \frac{2}{7})$, $(\frac{3}{8} + \frac{2}{3} + \frac{1}{12})$, $(\frac{16}{9} + \frac{2}{3})$, $(\frac{3}{5} + \frac{17}{10})$, $(\frac{243}{16} + \frac{7}{24})$.

Perform the following subtractions:

$(\frac{3}{8} - \frac{1}{12})$, $(\frac{17}{16} - \frac{7}{24})$, $(\frac{814}{144} - \frac{13}{16})$, $(\frac{430}{864} - \frac{104}{288})$, $(\frac{17}{64} - \frac{1}{4})$.

In the operation of multiplication and division we should always distinguish between the *operator* and the *subject* or *thing operated on.* Thus in 6 times 5, the number 6 is the operator and 5 is the subject. The latter is usually the measure of some quantity. The former is the sign of an operation to be performed, and this distinction, which is most important, must not be forgotten.

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[7] Multiplication of Fractions. We shall first consider the operator as a whole number and the subject as a fraction. Thus suppose that we wish to multiply $\frac{5}{12}$ by 6. The operation is exactly the same as if we wished to multiply 5 inches by 6. The result in the latter case is 30 inches and in the former it is 30 twelfths, or as we may write it: $\frac{30}{12}$, or by reduction $\frac{5}{2}$, or $2\frac{1}{2}$. This illustrates the familiar principle that to multiply a quantity we must multiply its measure, and since in a fraction the numerator is the measure, we multiply the numerator to multiply the fraction.

Furthermore it is plain if we *multiply* the denominator of a fraction that we *decrease* the size of the fractional unit, and hence with the same numerator or same number of such units we *decrease* the value of the fraction in like proportion. Similarly if we *divide* the denominator we *increase* the size of the fractional unit, and hence with the same numerator or same number of such units we *increase* the value of the fraction in like proportion. Hence if we can divide the denominator of the fraction by the given multiplier and leave the numerator the same, it will have the same effect as multiplying the numerator and leaving the denominator the same. Thus $\frac{7}{12} \times 3 = \frac{7}{4}$.

This may also be seen by first multiplying the numerator and then reducing to lowest terms. Thus $\frac{7}{12} \times 3 = \frac{21}{12} =$ by reduction $\frac{7}{4}$. Hence we have the following rule for multiplying by a whole number:

Rule—Multiply the numerator of the fraction or divide the denominator of the fraction by the given number.

Problems—Perform the following multiplications:

$\frac{2}{3} \times 2$, $\frac{2}{3} \times 3$, $\frac{6}{11} \times 4$, $\frac{7}{12} \times 6$, $\frac{19}{14} \times 7$, $\frac{21}{36} \times 12$, $\frac{27}{432} \times 36$.

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[8] Division of Fractions. As before, we first consider the divisor or *operator* as a whole number, and the dividend or subject as a fraction. Then we may remember that division is simply the inverse of multiplication, and that by inverting the procedure for the latter we shall effect the former. Thus to divide $\frac{18}{23}$ by 2 we divide 18 by 2 and have $\frac{9}{23}$ as the result. Or again we may multiply the denominator, thus dividing the value of the fractional unit and thus dividing the value of the fraction as explained in [7]. Thus $\div 2 =$. This being reduced to its lowest terms gives $\frac{9}{23}$ as before.

The operations on fractions involved in multiplication and division by whole numbers may be summarized as follows:

Multiplying the $\left\{\begin{matrix}\text{numerator}\\\text{denominator}\end{matrix}\right\}$ $\left\{\begin{matrix}\text{multiplies}\\\text{divides}\end{matrix}\right\}$ its value, and dividing the $\left\{\begin{matrix}\text{numerator}\\\text{denominator}\end{matrix}\right\}$ $\left\{\begin{matrix}\text{divides}\\\text{multiplies}\end{matrix}\right\}$ its value.

Problems—Perform the following divisions:

$\frac{6}{7} \div 4$, $\frac{2}{9} \div 3$, $\frac{6}{17} \div 2$, $\frac{21}{35} \div 7$, $\frac{16}{23} \div 4$, $\frac{15}{6} \div 3$, $\frac{231}{144} \div 11$.

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[9] Multiplication and Division by Fractions. In these operations the *operator* is expressed as a fraction, and the latter in this case is therefore not the measure of a quantity, but the sign of something to be performed. When the fraction is used as a multiplier it is simply a short-hand way of expressing two operations (1) a multiplication by the numerator and (2) a division by the denominator. Thus if $\frac{2}{3}$ is used as a multiplier it is simply a short-hand way of expressing a multiplication by 2 and a division by 3. Thus $8 \times \frac{2}{3}$ is another way of expressing $8 \times 2 \div 3$ or $8 \div 3 \times 2$.

Similarly and since division is exactly the inverse of multiplication, when a fraction is used as a divisor it is simply a short-hand way of expressing two operations, (1) a division by the numerator and (2) a multiplication by the denominator. Thus if $\frac{2}{3}$ is used as a divisor it is simply a short-hand way of expressing a division by 2 and a multiplication by 3. Thus $8 \div \frac{2}{3}$ is another way of expressing $8 \div 2 \times 3$ or $8 \times 3 \div 2$.

When the thing operated on is also a fraction these principles work out as follows: $\frac{3}{4} \times \frac{2}{5}$ means that $\frac{3}{4}$ is to be multiplied by 2 and divided by 5. But we can multiply by multiplying the numerator, and we can divide by multiplying the denominator. Hence $\frac{3}{4} \times \frac{2}{5} = \frac{3 \times 2}{4 \times 5} = \frac{6}{20} = \frac{3}{10}$. Hence for the multiplication of one fraction by another we have the usual rule as follows:

Rule—Multiply together the two numerators for a new numerator and the two denominators for a new denominator, and the fraction thus formed is the product desired.

Similarly for division, $\frac{3}{4} \div \frac{2}{5}$ means that $\frac{3}{4}$ is to be divided by 2 and multiplied by 5. But this is the same as the pair of operations expressed by using $\frac{5}{2}$ as a multiplier. Hence $\frac{3}{4} \div \frac{2}{5} = \frac{3}{4} \times \frac{5}{2} = \frac{15}{8}$

Hence for the division of one fraction by another we have the usual rule as follows:

Rule—Invert the terms of the divisor and proceed as in multiplication.

This might naturally be expected by remembering the relation between multiplication and division, and that one is the exact inverse of the other.

For the multiplication of a series of fractions into each other these principles work out as follows: $\frac{1}{2} \times \frac{3}{5} \times \frac{2}{7} \times \frac{5}{9}$ means that $\frac{1}{2}$ is first considered as the subject and $\frac{3}{5}$ as an operator. Then the result of this is the subject and $\frac{2}{7}$ is the operator and so on. The final result will be therefore $\frac{1 \times 3 \times 2 \times 5}{2 \times 5 \times 7 \times 9} = \frac{30}{630}$. In this result we have a numerator 30 whose factors are the numerators of the individual fractions, while similarly the denominator 630 has for its factors the individual denominators. Applying here the principles of [4] we may cross out from numerator and denominator any pair of common factors. This will shorten the operation and give the result in its lowest terms. Thus shortened the above case becomes:

$$\frac{1 \times \cancel{3} \times \cancel{2} \times \cancel{5}}{\cancel{2} \times \cancel{5} \times 7 \times 9} = \frac{1}{21}$$

The propriety of striking out a common factor in both numerator and denominator may also be seen by remembering that such a pair of factors denote, one a multiplication and the other a division by the same number. These operations will offset each other and may therefore be omitted entirely.

CANCELLATION. This striking out of common factors from both terms of a fraction is known as *cancellation*, and is often of great value in simplifying an operation before proceeding with the actual multiplication and division. The following are additional illustrations.

$$\frac{14}{33} \times \frac{16}{42} \times \frac{21}{8} \times \frac{22}{18} = \frac{\cancel{14} \times \cancel{16}^{2} \times \cancel{21}^{7} \times \cancel{22}^{1}}{\cancel{33} \times \cancel{42}^{3} \times \cancel{8}^{1} \times \cancel{18}^{9}} = \frac{14}{27}$$

$$\frac{4}{81} \times \frac{15}{16} \times \frac{16}{60} \times \frac{27}{2} = \frac{\cancel{4}^{1} \times \cancel{15}^{1} \times \cancel{16}^{1} \times \cancel{27}^{3}}{\cancel{81}^{3} \times \cancel{16}^{1} \times \cancel{60}^{4} \times \cancel{2}^{1}} = \frac{1}{6}.$$

We often meet with expressions like $\frac{2 \times 3 \times 16}{9 \times 8}$ in which the number of factors in numerator and denominator is not the same. All such expressions represent a series of multiplications of whole numbers and fractions as $\frac{2}{3} \times \frac{3}{8} \times 16$, or they may be considered as denoting a series of operations of multiplication and division, and in either case it follows that their reduction may be effected by cancellation as just described. Still otherwise we may consider such expressions as consisting of a numerator and denominator each resolved into factors, and hence in ready condition for reduction by cancellation. Thus in the expression above we have:

$$\frac{2 \times \cancel{8}^{2} \times \cancel{16}^{2}}{\cancel{8}^{3} \times \cancel{8}^{1}} = \frac{4}{3}$$

Problems—Perform the following operations:

$(\frac{2}{3} \times \frac{6}{7})$, $(\frac{2}{5} \times \frac{7}{8})$, $(\frac{3}{7} \times \frac{12}{11})$, $(\frac{8}{27} \times \frac{3}{8} \times \frac{3}{3})$, $(\frac{6}{17} \times \frac{15}{8} \times \frac{1}{3})$, $(\frac{2}{3} \times \frac{4}{5} \times \frac{25}{8})$.

$(\frac{16}{3} \div \frac{4}{7})$, $(\frac{28}{9} \div \frac{7}{3})$, $(\frac{17}{144} \div \frac{13}{24})$, $(\frac{42}{65} \div \frac{7}{13})$, $(\frac{8}{23} \div \frac{7}{16})$, $(\frac{3}{5} \div \frac{17}{6})$.

[10] COMPLEX FRACTIONS. In complex fractions either or both numerator and denominator may consist of fractions or mixed numbers.

Thus for example: $\frac{2\frac{1}{2}}{\frac{3}{5}}$, $\frac{\frac{1}{3}}{\frac{2}{7}}$, $\frac{\frac{2}{5}}{3\frac{1}{5}}$.

All such expressions may most conveniently be considered as ways of indicating operations, the numerator being the subject of the operation and the denominator being the operator expressed as a divisor.

Thus

$$\frac{2\frac{1}{2}}{\frac{3}{5}} = 2\tfrac{1}{2} \div \tfrac{3}{5} = \tfrac{5}{2} \div \tfrac{3}{5} = \tfrac{5}{2} \times \tfrac{5}{3} = \tfrac{25}{6}.$$

$$\frac{\frac{1}{3}}{\frac{2}{7}} = \tfrac{1}{3} \div \tfrac{2}{7} = \tfrac{1}{3} \times \tfrac{7}{2} = \tfrac{7}{6}.$$

$$\frac{\frac{2}{5}}{3\frac{1}{5}} = \tfrac{2}{5} \div 3\tfrac{1}{5} = \tfrac{2}{5} \div \tfrac{16}{5} = \tfrac{2}{5} \times \tfrac{5}{16} = \tfrac{1}{8}.$$

The reduction of such expressions becomes therefore simply a matter of the application of the rules and methods already given.

Problems—Reduce the following:

$$\frac{3\frac{2}{3}}{8\frac{4}{5}}, \quad \frac{\frac{1}{2} + 2\frac{1}{3}}{\frac{2}{3} - \frac{6}{5} \times \frac{1}{3}}, \quad \frac{\frac{4}{5} - \frac{3}{2} \div \frac{5}{2} + \frac{3}{10}}{2\frac{2}{5} \times \frac{5}{6} - 1\frac{3}{8}}.$$

§ 2. DECIMAL FRACTIONS.

[1] In decimal fractions the denominator is always 10, 100, 1000, etc., or some power of 10. Instead of writing them in the usual way, however, a device is made use of to indicate the denominator without actually writing it. This is simply to write the numerator and to place a *dot* at such a point that there shall be as many figures on the right as there are ciphers in the denominator, using ciphers to the left of the significant figures if necessary to make up the needed number of places. In writing a mixed number the whole number part stands on the left of the *dot or decimal point*, which thus becomes a point of separation between the whole number and the fraction.

Thus

$\frac{7}{10}$	is written	.7
$\frac{7}{100}$	" "	.07
$\frac{7}{1000}$	" "	.007
$\frac{23}{10000}$	" "	.0023
$2\frac{7}{10}$	" "	2.7
$162\frac{43}{1000}$	" "	162.043

In each case it is seen in the decimal that there are as many places on the right of the dot as there are ciphers in the denominator, and in this way the value of the denominator or unit of measure is indicated. There are no principles involved in decimal fractions different from those already discussed in common fractions, and the only difficulties in using them arise from the peculiar manner in which they are written. We will therefore give without further discussion the rules for the handling of decimals, all of which may be seen to follow from the principles already laid down.

[2] TO REDUCE DECIMALS TO LOWER TERMS. Evidently all ciphers standing on the right of the decimal may be struck off as they disappear from both numerator and denominator. Thus .3500 = .35.

[3] TO RAISE DECIMALS TO HIGHER TERMS. Add ciphers to the right of the numerator as may be desired. Thus .35 = .350 = .3500.

[4] TO REDUCE A DECIMAL FRACTION TO A COMMON FRACTION. Write the numerator and denominator as in common fractions and reduce to lower terms if possible.

Example—Reduce .35 to a common fraction.

Operation: $.35 = \frac{35}{100} = \frac{7}{20}$.

[5] TO REDUCE A COMMON FRACTION, PROPER OR IMPROPER, TO A DECIMAL. Take the numerator for the dividend and the denominator for the divisor and proceed as in division of whole numbers, adding ciphers to the right of the dividend as may be necessary. Then point off according to the following rule:

If the numerator or dividend is less than the denominator or divisor, the first figure of the quotient must stand on the right of the decimal point as many places as the number of ciphers added to the right of the dividend in order to enable it to contain the divisor. If the dividend is greater than the divisor place the point after the figure of the quotient given by bringing down the last figure of the dividend in the operation of division.

It should be noted that this gives the general method for dividing one whole number by another and expressing the result decimally.

Examples—Reduce $\frac{16}{250}$ to a decimal.

Operation:

$$250) \begin{array}{l} 1600 \\ 1500 \end{array} \Big(.064$$

$$\begin{array}{l} 1000 \\ 1000 \end{array}$$

Two ciphers are annexed in order to obtain the first figure 6 in the quotient. Hence this figure must stand in the second place to the right of the decimal point, and a cipher is added on the left of the 6 to bring it to this position.

Reduce $\frac{1647}{25}$ to a decimal.

Operation:

$$25) \begin{array}{l} 1647 \\ 150 \end{array} \Big(65.88 \quad , \quad \begin{array}{l} 220 \\ 200 \end{array}$$

$$\begin{array}{l} 147 \\ 125 \end{array} \qquad \begin{array}{l} 200 \\ 200 \end{array}$$

The figure 5 of the quotient is given by bringing down the last figure 7 of the dividend, and hence the decimal point must come between this and the next figure of the quotient.

Problems—Reduce the following to decimals:

$\frac{2}{5}$, $\frac{12}{5}$, $\frac{122}{5}$, $\frac{18}{250}$, $\frac{17}{130}$, $\frac{18}{4}$, $\frac{143}{55}$, $\frac{1721}{1440}$, $\frac{18}{9600}$, $\frac{14}{1900}$, $\frac{23}{7}$.

[6] To Add Decimals. Set down the decimals in a column so that the points shall all stand under each other. Then add as in whole numbers and bring down the decimal point in the sum under those standing above.

Example—Add .025, .64, .231, .4685, .003.

Operation:[3]

.025
.64
.231
.4685
.003
1.3675

[7] To Subtract Decimals. Set down the subtrahend under the minuend, the two decimal points one under the other, adding ciphers to the right if necessary to fill out to the same number of places. Then subtract as in whole numbers and bring down the decimal point under those above.

Example—Subtract .263 from .83.

Operation:

.830
.263
.567

[8] To Multiply Together Two Numbers Expressed Decimally. Multiply as in whole numbers and point off for the decimal portion as many places as there are in the two factors taken together.

Examples—

.16 × 24. = 3.84
72. × .0004 = .0288
.162 × .041 = .006642
21.14 × 13. = 274.82
21.14 × .13 = 2.7482
21.14 × 1.3 = 27.482

Problems—Perform the following multiplications:

2.72 × 1.4
143.26 × 24.2
12.16 × .018
4214.3 × 22.3
.14 × .21
.06 × .0084

[9] To Find the Quotient of Two Quantities Expressed Decimally. Clear both dividend and divisor of decimals by moving the point to the right an equal number of places in each, adding ciphers as may be necessary. The number of places moved will be that necessary to clear the term of higher order. Thus modified, consider the two terms as whole numbers and proceed with the division, pointing off according to the rule given above for the reduction of a common fraction to a decimal.

Examples—

$.16 \div 2.5$ or $\frac{.16}{2.5} = \frac{16}{250} = .064$

$1.6 \div 2.5$ or $\frac{1.6}{2.5} = \frac{16}{25} = .64$

$1.6 \div .25$ or $\frac{1.6}{.25} = \frac{160}{25} = 6.4$

$16 \div .025$ or $\frac{16}{.025} = \frac{16000}{25} = 640$

$.016 \div 250$ or $\frac{.016}{250} = \frac{16}{250000} = .000064$

$1.6 \div .243$ or $\frac{1.6}{.243} = \frac{1600}{243} = 6.5761 +$

Problems—Perform the following divisions.

7.25 ÷ 16
72.54 ÷ 6.4
.00864 ÷ 14400
8.64 ÷ .0144
96 ÷ .024
1.25 ÷ .0025

[3] If desired, the numbers may be filled out all to the same number of places, by adding ciphers on the right, such operation being, in fact, the reduction of the decimals all to the same denominator or unit of measure. In the summing, however, such ciphers play no part, and therefore the filling out is unnecessary in the actual operation.

§ 3. PERCENTAGE.

[1] In percentage, fractional relations are expressed decimally, but it is understood that the denomiator shall always be 100. The fractional unit is therefore always one one-hundredth of the principal unit, and therefore occupies to it the same relation as that of the cent to the dollar. The words *per cent* are commonly represented by the symbol % so that 16% is the same as 16 per cent or .16, while 5% equals similarly .05, etc. Care must be had not to fall into confusion with the use of both the decimal point and the % mark. Thus .4% is not .4 but .4 of one per cent or .004. A number written in percentage is usualiy an operator, and not a quantity or measure by itself. Thus 16% is not a quantity by itself, but rather expresses the relation between two quantities, or represents an operation to be performed on one quantity in order to obtain another. The handling of percentages is the same as that of decimals, remembering that the term *per cent* is simply a special name for a fractional unit one one-hundredth of the principal unit, whatever the latter may be, and that it is with this fractional unit that all quantities are measured in percentage operations. Remembering the rules for decimals we readily see the following:

Examples—

16% of 80 = 80 × .16 = 12.8
3% of 2.1 = 2.1 × .03 = .063
23% of $145.24 = $145.24 × .23 = $33.4052, or $33.41.

From the above it follows that:

To reduce any number expressed in per cent to terms of decimals, we divide by 100 and express the result decimally, or shift the decimal point two places to the left; while to reduce any decimal to terms of per cent we multiply by 100 or shift the decimal point two places to the right.

Thus:

.16 = 16.%
1.60 = 160.%
.016 = 1.6%
.0016 = .16%

To Find the Percentage Ratio Between Two Numbers.

Rule—Multiply the dividend or numerator by 100 and then divide and express the result as a decimal according to the rules of § 2 [9].

Thus: $7 \div 25$ or $\frac{7}{25} = \frac{700}{25}\% = 28\%$.

Similarly:

$3 \div 50$ or $\frac{3}{50} = 6\%$

$7 \div 16$ or $\frac{7}{16} = 43.75\%$

$6.4 \div 160$ or $\frac{6.4}{160} = 4\%$

$6.4 \div 16$ or $\frac{6.4}{16} = 40\%$

$$6.4 \div 1.6 \text{ or } \frac{6.4}{1.6} = 400\%$$

$$6.4 \div .16 \text{ or } \frac{6.4}{.16} = 4000\%$$

In percentage problems it is usually required to find certain percentages of various quantities, or to find the percentage relations between various quantities. The only difficulty likely to arise is not with the operations themselves, but with a correct interpretation of the problem and a clear understanding as to the relations desired.

Examples—

(1) A broker buys a ship for $160,000 and sells her for $172,000. What per cent does he gain?

Solution: The amount of gain is $12,000. To find what per cent this is of $160,000 we proceed as above and find 12,000 ÷ 160,000 = 7.5%.

(2) A broker buys a ship for $160,000 and sells her so as to gain 6%. What was the selling price?

Solution: Six per cent of $160,000 = .06 × $160,000 = $9,600. Hence selling price = $160,000 + $9,600 = $169,600.

(3) A broker sells a ship for $171,200 and thereby gains 7% on her cost. What was the cost?

Solution: Since he gains 7% or 7 cents on every dollar of cost, there will be $1.07 in the selling price for every $1.00 in the cost price. Hence the cost price will be as many dollars as 1.07 is contained in 171,200 or 160,000.

Problems—

(4) Thirty-six pounds of gun metal contain the following:

Copper	32 pounds
Tin	1 pound
Zinc	3 pounds

Find the percentage composition.

Ans. Copper $\frac{32}{36}$ or 88.89%
Tin $\frac{1}{36}$ or 2.78%
Zinc $\frac{3}{36}$ or 8.33%

(5) A ship starts on a voyage of 2,200 miles. After going 800 miles what per cent of the voyage remains to be covered?

Ans. 63.6%.

(6) A ship starts on a voyage of 1,800 miles. After three days she has made 42% of the distance. With 12% increase of speed for the rest of the time how long will it take her to finish the voyage?

Ans. 6.3754 days.

(7) A marine engine requires 2.1 lbs. of coal per I. H. P. per hour. After certain changes are made the figure is reduced to 1.89 lbs. What is the percentage gain?

Ans. 10%.

On one ton of coal (2,240 lbs.) there was found to be 250 lbs. of ashes. What per cent of the coal was combustible?

Ans. 88.8%.

An interesting meeting of the Civil Engineers' Club, of Cleveland, was held in the Case Library on the night of September 13 last. W. R. Warner presided in the absence of the regular officers. The question of changing the name of the club to "The Cleveland Society of Civil Engineers" was discussed and put to a vote, which resulted adversely. Another proposition to rename the organization "The Cleveland Technical Society" was also negatived. At the next meeting the members will consider the adoption of the name "The Cleveland Society of Engineers." In the technical proceedings an interesting paper was read by John P. Coffin, entitled "Some Points of Interest Gathered from an Inspection of the Machinery of Vessels on the Great Lakes, Together with a Synopsis of the Rules Compiled by the Great Lakes Register for Future Construction, and the Reasons for the Same." The paper was a condensation of the results of surveys of about 1,300 vessels. In the paper mention was made of certain defects in design and proportion of machinery.

ELECTRICITY ON BOARD SHIP, PRINCIPLES AND PRACTICE.—XIII.

BY WM. BAXTER, JR.

As was shown in the last article, it is perfectly possible to convey the current of one or more generators to the circuits in which it is used by the crudest kind of wiring connections, so long as the necessary indicating instruments and operating switches are placed in the proper relation in the connecting wires. The convenience of handling the plant in the future, however, can be greatly increased by arranging the connections, and the instruments and switches in a systematic manner; and it is found by experience that the best way of accomplishing this is by constructing what is commonly called a switchboard, which may be defined as a center of distribution, as from it the currents delivered by the generators are directed into the various external circuits.

Switchboards may be very simple or very complicated, according to the service they are required to do. The simplest form of switchboard is that used in connection with a single generator. These can be made in an almost endless variety of forms. Fig. 64 shows about the simplest construction. In this diagram the outline *K* represents the board, the diagrammatic representation of the generator being directly over it. *C* represents a circuit breaker of what is called the two pole type, the name being derived from the fact that it opens the circuit on both sides of the generator armature. As will be seen, the wires *a b* which carry the generator current, pass through this circuit breaker, *a* running down the left side and thence through the ammeter *Am* and to the point *c* on the heavy broken line *1*. The wire *b* passes down the right side of *C* and connects with the heavy broken line *2* at *d*. When the circuit breaker *C* acts, the connection between *r r'* and that between *t t'* are broken, thus entirely disconnecting the generator from the lines *1* and *2*. From the points *h* and *k* wires are run to the voltmeter *V*. The rheostat for regulating the current in the shunt field coil *S* is located at the bottom of the board as shown at *R*. The two lines *1* and *2* are called bus bars and are used so as to facilitate the connection of the external circuit wires. At *s s s s* are shown four switches, one side of each being connected with bus *1* and the other with bus *2* by their upper contacts. The lower contacts *m n* are connected with the wires leading to the external circuit. With this construction it can be seen that if any of the switches *s* are closed, that is, so as to make a metallic connection between the upper and the lower contacts, that then a current will pass from the bus bars to the circuit with which the switch connects, but if the switch is open no current will flow into that circuit. As the switches are side by side, the supply of current to any part of the external system can be controlled in the most convenient manner. The voltmeter being upon the board shows at all times the pressure of the current, and the regulating rheostat being directly under it the handle of the latter can be moved so as to effect the necessary regulation in the most satisfactory manner, for the attendant can observe the effect of the change in the resistance upon the voltage by simply looking up at the voltmeter, while moving the rheostat handle. It is not always customary to keep the voltmeter constantly in circuit as instruments of this kind that can withstand such strain are expensive. When cheaper instruments are used for the purpose of testing the voltage, from time to time, a small switch is inserted in one of the wires running to the points *h k*, this switch being made with a spring that keeps it normally open.

The construction of switchboard shown in this figure is about the simplest that can be used. Gener-

ally, a main switch is provided which is located at one side of the circuit breaker *C*, or below it, and frequently circuit breakers are provided in each one of the branch circuits taken from the bus bars through the switches *s s s s*. When circuit breakers are used in these branches they are placed between the switches and the bus bars. With the construction shown in the diagram it would be necessary to provide the branch circuits with safety fuses, and these can be located at the lower end of the switchboard, at the sides of the rheostat *R*, or they may be placed back of the board, providing their location is such that they can be readily reached whenever renewals of fuses are required.

When switchboards first came into use the board *K* was placed against the side of the dynamo room; it was made of wood and the instruments and switches, all upon their own bases, were fastened to the board, and all the wire connections were upon the surface. It was soon found that the apparatus could be rendered more convenient and attractive by placing all the wires back of the board, and setting this far enough from the wall to afford free access behind it. It was next found that wooden boards were liable to be set on fire by the flashing of the circuit breakers and large switches, therefore marble and slate were substituted in the construction of *K*.

When more than one generator is used, the simplicity of switchboard construction shown in Fig. 64, apparently, has to be departed from, but in reality there is no more complication in one case than in the other; there is simply a duplication of the various parts. This can be made quite evident by means of Figs. 65 and 66, which are diagrammatic representations, in a simplified form, of switchboards for three generators, the first being arranged to feed into one system of external distribution, and the other to feed into three independent systems. In both figures, the volt and ammeters as well as the switches, circuit breakers and field regulating rheostats are omitted so as to leave only the skeleton outlines of the main circuit wires. In Fig. 65, the lines *1*, *2* and *3* are the bus bars, *1* being known as the equalizing bus, and taking the place of wire *B* of Fig. 63. Buses *2* and *3* are the terminals to which the external circuits are attached. As there are three generators, it will be evident, at once, that these should be so arranged that any one may be disconnected from the circuit whenever desired, hence, there must be a switch by means of which the connection between each generator and the bus bars may be broken. It is also evident that for one reason or another, the

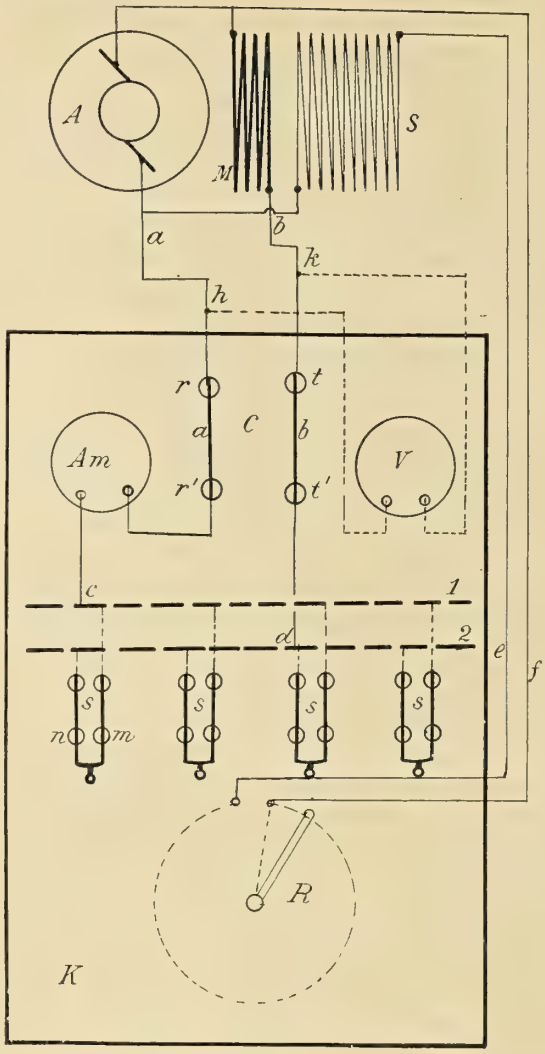
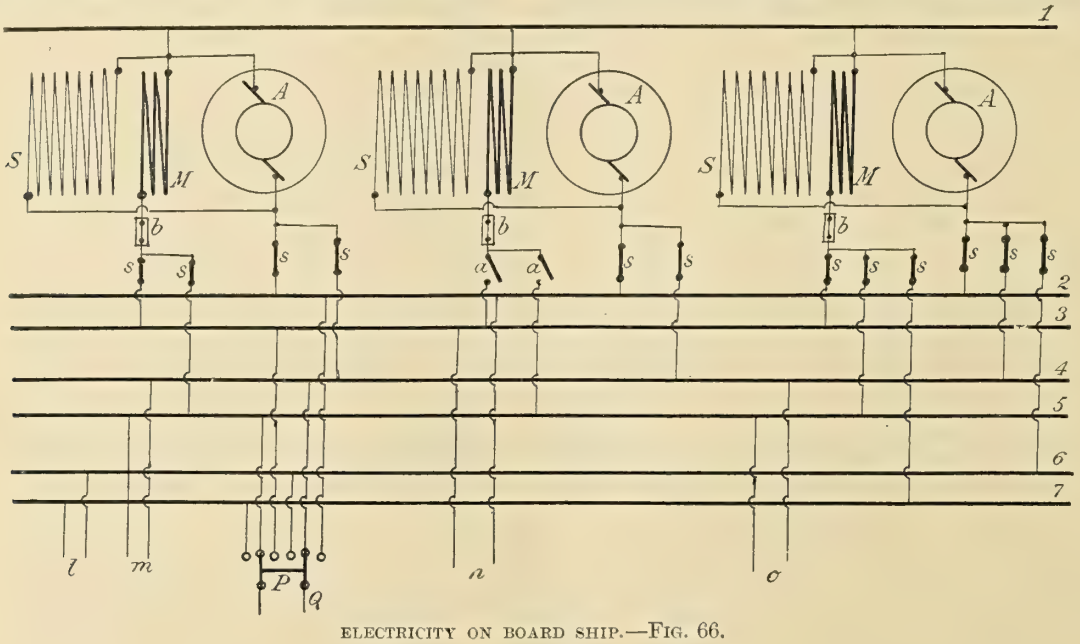


FIG. 64.



ELECTRICITY ON BOARD SHIP.—FIG. 66.

current passing through any one of the generators may become dangerously strong, hence, each machine should be provided with an independent circuit breaker. As to the external circuits *a*, *b*, *c*, *d*, it is also clear that it may be desirable to disconnect these sometimes, and also that it is possible for the current flowing in any one to become greater than the wire can carry with safety, therefore, each one of these circuits should be provided with an independent switch and an independent circuit breaker. In the way of instruments, it is desirable to have an ammeter and a voltmeter for each generator, and it is also desirable to have an ammeter and voltmeter to indicate the total current passing into the external circuit as well as the actual voltage acting upon the line.

In a case such as shown in Fig. 66, when there are a number of independent external systems of distribution as well as a number of generators, it is not only necessary to arrange the machines so that any one can be disconnected, but it is also desirable, if not actually necessary, that means be provided whereby any machine may be connected with any of the external circuits. In the figures the two machines on the left are shown with connections leading to two sets of bus bars, and the generator to the right is shown connected with all the buses. By means of the switch *S S S*, the generators can be arranged to feed into all the buses with which they connect, or with any one of them. By means of switches constructed as shown at *P*, any of the external circuits can be transferred from one system to any other. From this it will be seen that when there are a number of generators, and these feed into two or more independent external systems, it is desirable, and in most cases necessary, to provide switches whereby any macine may be connected with any external system, or may be entirely disconnected from all; and also to provide switches by means of which any part of the external circuit may be transferred from one system to any other or be disconnected from all. It will further be realized, that there is no special difficulty in the way of accomplishing all these results, and this fact will be made still clearer in the succeeding articles.

An important transfer of manufacturing interests in the electrical field has recently taken place in the purchase by the Westinghouse Electric & Manufacturing Co. of the stocks and bonds of the Walker Company. The principal owners of the latter company will, it is understood, get an interest in the consolidated company and seats in the board of directors.

ENGINEERS' DICTIONARY—X.

Cock.—A device for controlling or directing the flow of a liquid, gas or vapor. The simple plug cock consists of a slightly tapering plug fitting a casing or chamber and having a hole or passage through from

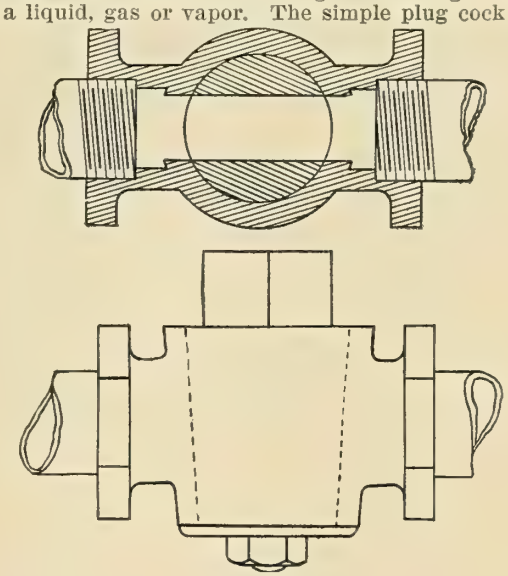


FIG. 29.

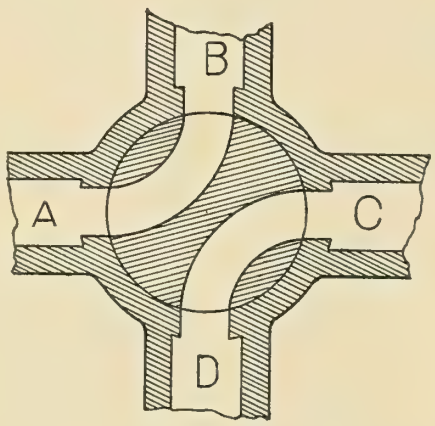
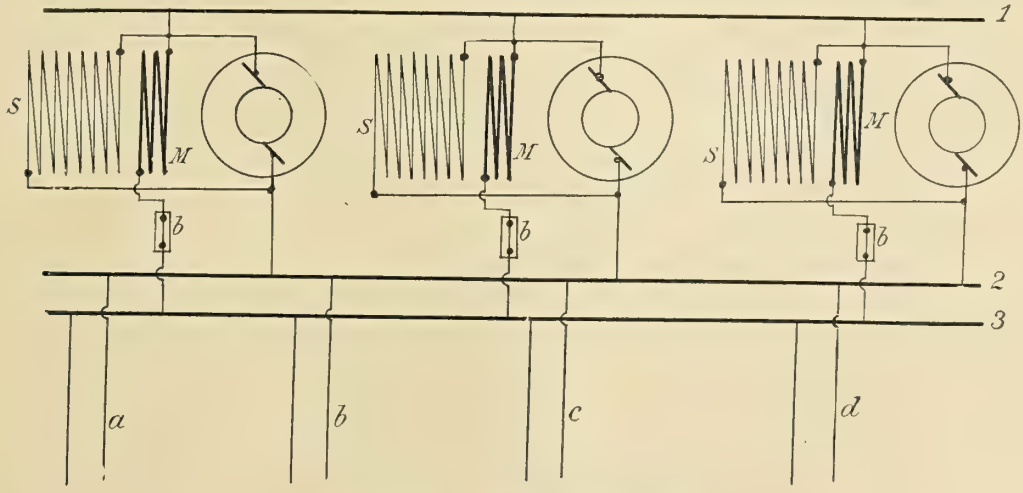


FIG. 30.



ELECTRICITY ON BOARD SHIP.—FIG. 65.

one side to the other, as shown in Fig. 29. The passage is open or closed, according to the position of the plug. In a cock of the form shown in Fig. 30 the passage *A* is connected to *B*, and *C* to *D*, while by a quarter turn *A* becomes connected to *D* and *C* to *B*.

Column.—The part of a vertical marine engine which directly supports the cylinders and connects them with the bed-plate. The guide surfaces for the cross-heads are also either formed on the columns or supported by them. Columns are made of cast-iron, cast-steel and forged-steel. When of cast metal they

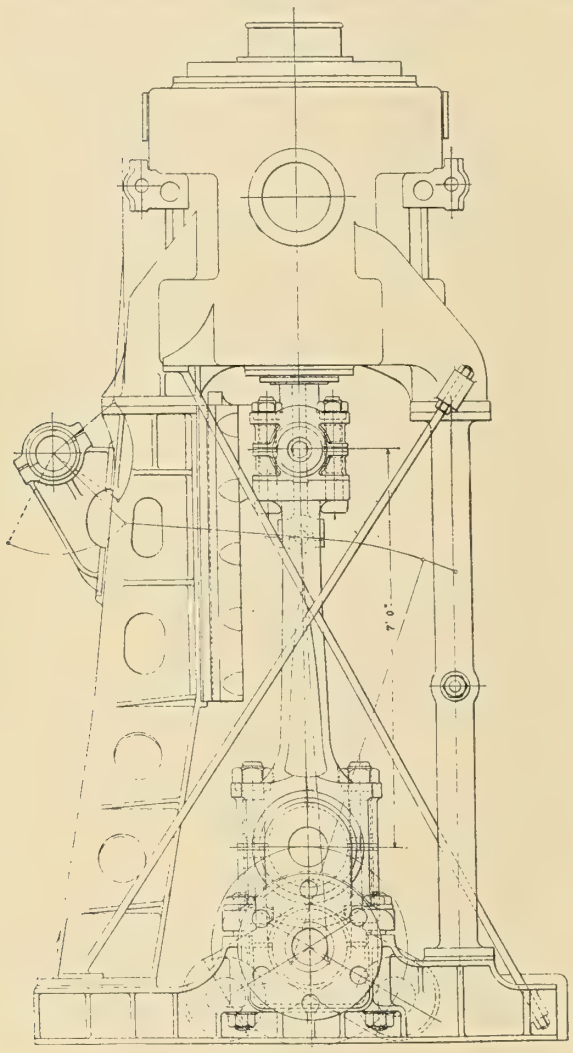


Fig. 31.

are usually in the form of an inverted Y and of hollow or box girder section. Such are therefore known as *inverted Y columns*. When forged they are cylindrical or slightly tapering, and sometimes hollow. Cast inverted Y columns on the back and cylindrical forged columns in front, as in Fig. 31, are very commonly used in marine practice at the present time, especially with single *slippers*.

Combustible.—That part of coal or other fuel which can be burned; or the fuel less the ash. For coal, the amount of combustible is usually from 85 to 95 per cent.

Combustion Chamber.—A chamber into which the products of combustion in a boiler pass before entering the tubes. Its chief purpose is to provide an opportunity for the completion of the combustion, especially of hydrocarbon gases given off from bituminous coal. See also under *boiler*.

Compression or *Cushion.*—In the cylinder of a steam engine the exhaust is usually closed before the piston has reached the end of the stroke. This results in the compression of the steam thus shut in, from the volume at the instant of closure to the volume of the clearance. This operation and this part of the cycle are known as the *compression* or *cushion*, and the operation is frequently termed *cushioning*.

Compound Engine.—An engine in which the total expansion is divided into two stages, the steam entering first the high-pressure or smaller cylinder, thence exhausting into the low-pressure or larger cylinder, and thence exhausting to the air or to the condenser.

Concentration or *Saturation.*—Terms used to denote the relative amount of solid matter in the water in marine boilers. See *Brine*. Ordinary sea water contains about one part in thirty-two of solid matter in solution, and this being taken as a standard its concentration is called 1. A concetration of 2 or 3 means, therefore, two or three times as high a proportion of solid matter as in common sea water. With surface condensers, but without fresh auxiliary feed from evaporators or tanks, the concentration on long runs will rise to 3 or 4, and is usually kept from higher values by occasionally blowing off a portion of the water in the boiler and replacing it with sea-water as an auxiliary feed. With fresh feed the concentration can be kept down to a value depending simply on the tightness of the condenser, and the absence of salt-water leaks into the feed. The concentration is tested by means of a special form of *hydrometer* or *salinometer*, as it is frequently called.

Condenser.—The apparatus by means of which the exhaust steam is reduced to the state of water. Condensers are of two types—*jet* and *surface*.

The former consists of a chamber of rectangular or cylindrical form in which the steam and water are intimately mingled by jet orifices. The condensed steam and water fall to the bottom of the chamber, and are thence removed by the air pump, a portion being taken by the feed pump for boiler feed.

The usual type of surface condenser, see Fig. 32, consists of a chamber commonly of cylindrical form if separate, or rectangular if forming part of the en-

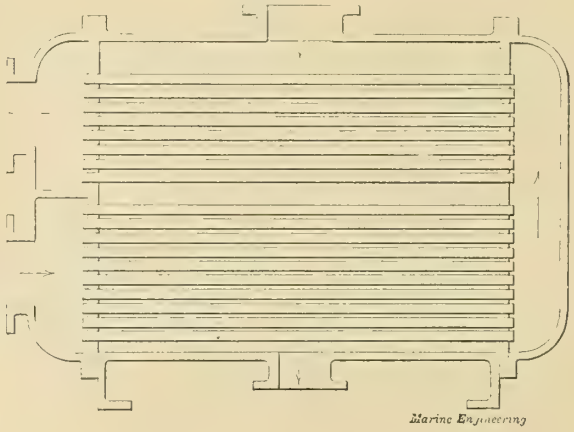


Fig. 32.

gine columns. This chamber contains, as shown, a large number of small brass tubes running between the inner walls of the heads, which are double. This form of head provides a connection between the ends of the various tubes. The condensing water is driven by the circulating pump through the tubes, while the steam is exhausted from the engine into the body of the chamber, and thus around the outside of the tubes. The steam and the condensing water are thus kept separate, and the steam is condensed simply by

the surface action of the tubes. The steam thus condensed to water falls to the bottom of the condenser, whence with some air and vapor it is removed by the air pump and delivered to the hot well, whence it is taken by the feed pump and sent back to the boilers. The amount of condensing surface is usually proportioned to the power developed by the engine, from 1 to 1.5 sq. ft. per I. H. P. covering the range of usual practice with modern triple-expansion engines.

Condenser-Tube.—A tube used in a surface condenser, usually of brass and 5-8 in. or 3-4 in. outside diameter.

Condenser-Tube Packing or Ferrule.—A form of packing used to make a water-tight joint between the condenser tubes and the inner heads or tube plates; and at the same time to avoid rigid constraint of the tube. The most common type of condenser tube packing is shown in Fig. 33. The tube plate is counterbored as shown and threaded for a ferrule with a

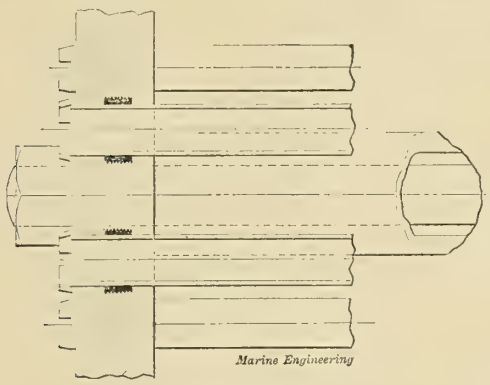


FIG. 33.

tapering outer end, and hence with a hole smaller than the outside of the tube, but not smaller than the inside. Between the end of the ferrule and the bottom of the counterbore is usually a ring of rubber or corset lacing as an elastic packing. Screwing down on the ferrule compresses the packing, and thus makes the joint. The tube is free to expand and contract slightly, but is prevented by the outer ends of the ferrules from crawling to such an extent as to free either end.

Cooling Surface.—Another name for *condensing surface.* See *Condenser.*

Corrosion.—The destruction of metals by chemical action. The usual forms of corrosion are two in number—*oxidation* or *rusting* and *acid* corrosion. The former is due to the union of oxygen with the metal. For the continuous rusting of iron or steel, three conditions are necessary: the continuous presence with the metal of *oxygen, moisture* and *carbonic acid.* A removal of any one of these will prevent continuous rusting. Painting insures the absence, more or less perfectly, of all three. Quicklime insures the absence of moisture as well as carbonic acid. Immersion in water made alkaline by lime or soda insures the absence of carbonic acid and oxygen except in slight amount. Acid corrosion is due to the union of the metal with an acid, which on board ship is very commonly *hydrochloric* or *muriatic* acid, according to the common name. Corrosion of this character may be counteracted by a protective coating not subject to the attack of the acid, or by insuring the presence of an alkali to neutralize the acid. Corrosion also depends much upon *electro-chemical* action, or to state the relation more generally, the electric relations of the different metals to each other and to a liquid with which they are in contact, and the consequent electrical actions, may increase very notably the amount of chemical activity.

QUERIES AND ANSWERS.

Q.—Are marine engines sufficiently governed to prevent racing at all times when the propeller is emersed. If not, why not?

Describe the most effective type of marine engine governor. W. G. H.

A.—The subject of governing a marine engine to prevent racing in a seaway is one on which considerable labor and experiment has been expended for the last 35 years, as the great variety of patents on governors will attest.

When steam was first introduced in vessels the engines were governed by hand, and as the main stop valves in those days were of simple construction they took considerable time to open or close, so a butterfly valve was placed in the main steam pipe which, although it would not close steam-tight, would effectually check the flow of steam to the engine, and could be operated very quickly. Later on automatic gear was installed in connection with the butterfly valve to take the place of the engineer at the lever. In latter years the butterfly valve has not been used to any great extent, as main stop valves are now balanced so that they can be operated quickly, and as with high pressure steam a small amount of priming will sometimes carry the butterfly valve along with it into the steam chest.

In modern triple and quadruple engines it is impossible to suddenly check by means of the throttle because the quantity of steam remaining in the intermediate and low pressure receivers, with the help of the vacuum in the condenser, will still cause the engine to run abnormally fast if it is relieved of its load. This fact was noticeable even in compound engines, and was remedied by connecting the automatic gear with a valve in a pipe running between the top and bottom of the low pressure cylinder, so that when the throttle valve closed the pressure was at the same time equalized in both ends of this cylinder by the opening of this equalizing valve.

Nowadays the automatic controlling gear is usually connected to the reversing gear, linking up all the valves at the same time, sometimes even throwing the links amidships, or linking up part way as necessary, and then linking full out again when the propeller is again submerged. This linking up has one disadvantage from the fact that it causes an excessive fluctuation of pressure in the valve chests and endangers the joints in the receiver pipes, so the latter must be made strong enough to withstand it.

It has often been asserted that the greatest strain in shafting occurs when the engine is running full power ahead with the propeller entirely submerged; an opinion which seems to be verified by the fact that by far the greatest number of breakages of shafts have happened when running under this condition. It is also well known that it is impossible to develop high power when the ship is laboring, as the firemen cannot stand up to their work as well as when in smooth water. It is also evident that a propeller which is stopped suddenly is a drag or detriment to the speed of the ship, and although the vibrations imparted to a vessel, especially a twin-screw vessel, by the blows of the blades of partially submerged propellers are very annoying, it is not good policy to stop them entirely, but to simply endeavor to reduce the revolutions in proportion to the depth of submersion.

It is difficult to design a gear which will properly control the engine under all conditions of draught, wind and weather; but nearly all the gears are so constructed that they can be adjusted to cope with varying conditions, as the latter do not change suddenly.

The large high-powered transatlantic liners nowadays are of deep draught and fitted with fast-running engines and propellers with large driving surfaces. These are of comparatively small diameter, and are submerged to a considerable depth, and as the great length of these ships prevents excessive pitching the question of the racing of the propellers is not so important as in liners of former years.

It would be out of place in this article to name any particular make of governor, but a short description of a few types and their action will probably be of aid to you.

Marine governors may be divided into two classes: those actuated by the pressure of the water under the stern of the

ship, and those actuated by any sudden increase in the normal speed of the engine. In the first variety a cock is attached to the inside bottom of the ship at the stern, connecting with an air vessel and, by means of a pipe, to a chest with a spring-loaded diaphragm in the engine room. The cock is of the three-way variety, so that the air vessel and pipe may be drained of water at any time that it may accumulate. When the cock connects the system with the sea the water pressure, due to the depth, compresses the air in the system, compressing the spring on the leather diaphragm. If, however, the stern should rise, the pressure would diminish and the spring will depress the diaphragm. In some cases the diaphragm is made large in diameter and is connected directly to the throttle lever; in other cases it is made quite small and operates the small piston valve of a steam cylinder, which is turn works the throttle valve and also the equalizing valve on the low-pressure cylinder. The tension of the spring on the diaphragm can be adjusted to suit the different conditions of weather, etc.

Of the second class, those actuated by an increase in revolutions, there are a greater number to chose from. Following is the description of a few types: A driving pulley, located at some convenient place on the shaft, revolves, by means of a belt, a small spring-ball governor similar to those used on land engines, the spindle of which controls the valve of the power gear connected to the throttle or reversing lever. In another type the belt drives a shaft with a helical spring attached at the end, the axis of both being identical. The free end of the spring has a fan paddle wheel attached, so that when the shaft is driven the fan is also revolved by means of the intervening spring. Any sudden increase in speed drives the fan faster, putting a greater resistance on the spring, tending to uncoil it, and the axial lengthening of the spring due to this operates the power gear to the throttle. In another type the fan works on a coarse-threaded screw and is held in place by a spring. The screw is driven by the belt, and any increase in speed will cause the fan to overcome the resistance of the spring and run back on the screw and operate the throttle gear. In another style of gear the increase of speed will cause weights controlled by springs to move outwards from the belt-driven shaft, after the manner of the ball governor, and engage an outer ring similar to a friction clutch, revolving the same and thus operating the throttle gear. The diaphragm has also been used in connection with the latter class of governors. The main engine shaft drives a small pump or turbine, which forces a liquid into a chest fitted with a spring-loaded diaphragm. The discharge pipe from the chest runs back to the suction of the pump or turbine, and can be throttled by means of a cock so that a certain pressure can be maintained in the chest at normal speed of the engine. When the engine suddenly increases in speed the pressure in the chest rises correspondingly, as the outlet has not the area to pass off the increased quantity of liquid, and consequently the diaphragm is compressed and controls the engine by means of intermediate gear.

At first sight it would seem that a pendulum would be a good device to operate a throttle gear. A following sea, however, will cause a ship to pitch when it lifts the stern and the propeller will still be under water, so the pendulum gear has been abandoned.

There is still another type of gear in use operated by increase of speed, but driven without the intervention of a belt. It consists of a small rod, with stoppers at each end and a weight sliding on it. The rod is attached to any oscillating part of the engine, preferably near the reversing or throttle gear and usually placed on the pump levers, the axis of the rod coinciding with the direction of motion. If the weight were not held fast it would bob up and down along the rod, due to the momentum imparted to it by the oscillations. The weight is pressed against one stopper by means of a spring, and the tension is so adjusted that the weight cannot move on the rod until the engine exceeds its normal speed, and then the momentum overcomes the tension, and the weight, bobbing on the rod, moves a small lever attached, operating the throttle or reversing gear. This type of governor is sometimes applied only as a safety gear to quickly throw the links amidships and let them remain there in case of breakage of a shaft, as an accident of this kind releases the engine from all load, so that it will race so fast as to fly to pieces unless it can be instantly controlled.

It is evident that in nearly all of these types it takes an appreciable amount of time to impart the movement of a small, delicate piece of mechanism through the different power multiplications to the throttle reversing gear, and this has been the main difficulty with many different gears, as they were so slow that the engine would race at first and only be checked when the propeller was again going under water. If, on the other hand, the gears could be made to work instantaneous, the engines would maintain uniform speed, which is also undesirable, as explained heretofore.

The best working governors are adjusted to check the motive power suddenly when the engine slightly exceeds the normal speed, as a gradual shutting off would not sufficiently overcome the momentum of the parts of the engine; they release quickly so as to make an allowance for the time consumed by the engine to acquire speed again. In other words, the governor over-run itself both ways.

A governor must be simple in construction, so that it will not be liable to get out of order. It must occupy little space, and that space to be in an out-of-the-way place so as not to interfere with the work around the engine, and also so arranged that it can quickly be thrown in and out of action.

Q.—Why is drilling better than punching for making holes in boiler plate? NAVY YARD.

A.—Drilling is better than punching because the metal of the plate is not so severely tried by the former operation as by the latter. In punching, a thin skin of metal about the hole is so severely strained that its strength, and especially its ductility and toughness, are reduced far below what they are in the remainder of the plate. This is not the case with the drilled holes, or at least not to anything like the same extent. Drilled holes may also be located more accurately than punched holes, and thus with the former the parts of a riveted joint may be more perfectly fitted than with the latter. The operation of drilling leaves, however, a sharp edge which should be removed by a reamer in order to avoid any tendency to cut the rivet. The punched hole is naturally somewhat tapering, and is therefore more directly suited to countersunk or flush-point riveting than the drilled hole. In the latter case, for this class of work, the hole must be reamed or drilled out tapering by a special operation. In spite of the greater cost of drilled holes, however, they are now generally accepted as the best for high-class work, and in many specifications no holes are allowed to be punched.

Q.—What are the relative sizes of compound engine cylinders? L. N.

A.—In the early days of compound engines, when the pressures employed were in the neghborhood of 100 lbs., the ratio between the areas of the two cylinders was usually not far from 2, which gave a ratio between the diameters of about 1.4 or 1.5. Not uncommonly three cylinder compounds were made with three cylinders of equal size, one for the H. P., and two acting together for the L. P. With the gradual rise in steam pressures the ratio between the cylinder areas has also increased until values of from 2.5 to 4 are met with. These correspond to diameter ratios of from 1.6 to 2.0. Extreme cases are also occasionally met with where the area ratio rises to 4.5 or 5, corresponding to a diameter ratio of from 2.1 to 2.3. Such engines have been likened, in proportion, to a triple-expansion engine with the I. P. cylinder removed.

Q.—How much air is required to burn one pound of coal? C. H. B.

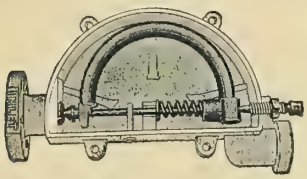
A.—The *burning* of coal means chemically its union with oxygen. It requires just 2 2-3 lbs. of oxygen to burn one pound of carbon, and practically the same amount for one pound of coal. The air, however, contains only about 23 per cent of oxygen to 77 per cent of nitrogen, so that the amount of air necessary to furnish 2 2-3 lbs. oxygen will be 2 2-3 ÷ .23, or 12 lbs. approximately. This, then, is the amount of air needed to just burn one pound of coal. Under actual conditions, however, much more than this must be supplied in order to provide sufficient draught, so that usually not less than about 20 lbs. is used, and with forced draught the figure will rise even above this.

The American Shipmasters' Association has changed its name to The American Bureau of Shipping. It was incorporated in 1862, and from a congregation of ships' officers has become an influential commercial body, hence the change of title.

Money to Burn?

Well, don't burn it that way, at least. Put on the "Heintz" Steam Trap wherever you have a pipe carrying steam from dryers, heaters, boilers, etc. It saves all waste steam. Even the smallest trap will discharge one gallon of hot water a minute. Operates on difference of one degree of temperature (211° to 212°), and is the only perfect trap made; the only one imitated. Its perfect action depends on a "tube spring" filled with a secret preparation, and the expansion of this spring makes the trap automatic, simple, long lived, perfect —20% to 30% of coal bills saved.

Inquiry will bring more information and some proofs. Ask for Booklet "G"



William S. Haines Company,

136 South Fourth Street, Philadelphia.

"The Heintz—the best—tho' it has imitators."

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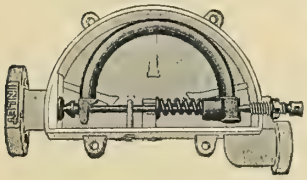
Cents Burn Easily

as dollar bills when you buy good steam coal, make steam, and then blow it out of unprotected outlets. You save every drop of waste oil, why don't you save steam, too? The "Heintz" Steam Trap (some of the many imitations look like the original) saves every ounce of steam. It's quick acting and constant—works on a mechanical principle—not on faith or theory.

The smallest size discharges one gallon of water per minute; the largest, 240 gallons per minute, and not a puff of steam lost. The valve operates instantly on difference of one degree—211° to 212°—saves the cost every month. Our Booklet "G" for the asking.



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TRADE PUBLICATIONS.

Users of marine glasses should send to the Bausch & Lomb Optical Co., Rochester, N. Y., for a pocket size catalogue of the new stereo field glasses.

The International Anchor Co., Cleveland, O., has issued a 16-page catalogue with many illustrations of a new anchor, which has just been put on the market.

A little eight page catalogue is issued by L. W. Ferdinand & Co., 184 Federal St., Boston, Mass., illustrating and describing the Stentor megaphone, which is made especially for marine uses.

"Helps in Brazing" is the title of a 12-page catalogue just issued by the Joseph Dixon Crucible Co., Jersey City, N. J. It treats of the process of brazing, and gives much practical information. Copies can be had upon application.

A card 6 by 9 in. in size is issued by Putnam & Co., 150 Nassau St., New York, giving illustrations of a large variety of trucks, scales, etc. It includes a line of these which are especially adapted for use on steam vessels, wharves, etc.

Pipe-threading and cutting machines, made by D. Saunders' Sons, Yonkers, N. Y., are illustrated and described in a supplemental catalogue, which will be sent to all inquirers. Several types of machines are illustrated with large cuts, and full descriptions accompany them.

A catalogue is received from Patterson, Gottfried & Hunter, Ltd., 148 Center St., New York, descriptive of a line of machine tools, including lathes, grinders, polishing machines, etc., such as would be used in any metal working establishment. These include the products of some of the best makers.

The gate and other valves, expansion joints and other special appliances manufactured by the Coldwell-Wilcox Co., Newburgh,, N. Y., are well illustrated and described in a 5 by 9 in. catalogue just issued. Every user of steam appliances should send for a copy of this and preserve it for future reference.

The Stow flexible shaft, manufactured by the Stow Mfg. Co., Binghamton, N. Y., is thoroughly illustrated in all of its applications in catalogue No. 7, a copy of which can be had upon application and by mentioning this publication. This catalogue comprises over 50 pages and contains a large amount of interesting matter.

A sixteen page pamphlet regarding Daniel's Patent P. P. P. Diagonal Rod Packing has been received. It is printed in two colors and is a plain business talk regarding this packing, its special qualities and manner of using. Any user of packing cannot fail to benefit by a perusual. Copies can be had from C. A. Daniel, 409 Market St., Philadelphia, Pa.

Pier and dock building, together with dredging and harbor improvement work and other lines of engineering and contracting, are fully illustrated in an exceptionally handsome catalogue just received from the New York Dredging Co., World Building, New York. The catalogue is 6 by 9 in. in size, and has many full-page illustrations. It comprises 56 pages, and is a valuable book for reference on the subjects indicated.

Pneumatic tools manufactured by the Chicago Pneumatic Tool Co., 122 Liberty street, New York, are very finely illustrated and described in two catalogues. One is devoted to riveters, hammers and drills, and the other to boring machines, drills and pneumatic painting machines. Practically every tool illustrated is particularly adapted to marine work, and many of our readers will wish to send for copies of these catalogues.

BUSINESS NOTES.

PICTURE OF THE OREGON.—Every reader of Marine Engineering sending his name and address to the Peerless Rubber Mfg. Co., 16 Warren street, New York, will have sent to him free a large picture of the battle ship Oregon in four colors, 15 by 22 in. in size.

TRAVELING FREIGHT RAMP.—Handlers of freight between vessels and wharves will be much interested in the traveling ramp illustrated and described elsewhere in these pages. This device is one of the latest productions of the Link Belt Engineering Co., Nicetown, Philadelphia, Pa.

A COMPLETE SUPPLY HOUSE.—U. T. Hungerford, 121 Worth street, New York, has fitted up his new building from cellar to ceiling with everything in the line of brass and copper goods. He is now in shape to submit prices promptly, and to send catalogues and any other information regarding anything made in these two metals.

STOCKLESS ANCHORS.—Business is reported as brisk with the Baldt Anchor Co., Chester, Pa. The general type of these anchors can be seen from the cut in the advertisement on another page, and full information regarding them can be had by sending to the company for one of the very neat catalogues issued covering this subject.

THE OREGON'S FORGINGS.—The performance made by the battleship Oregon in steaming from San Francisco to Key West without a break-down in her machinery has won the admiration of engineers, and especially of those interested in marine machinery. The crank shafts, line shaft, thrust shaft and propeller shaft were all hollow forgings, having a 6-in. hole through them. They were manufactured by the Bethlehem Iron Co., South Bethlehem, Pa.

GARLOCK GASKETS.—Engineers who experience trouble with leaking man-hole and hand-hole plates should try the Garlock Cut Gasket. It is manufactured only by the Garlock Packing Co., Palmyra, N. Y. Prices and catalogues will be mailed on application to the main offices and factories, Palmyra, N. Y., or Rome, Ga., or from any of their salesrooms, New York, Boston, Philadelphia, Pittsburg, Cleveland, St. Louis, Denver. The Garlock Cut Gasket is also sold by the leading dealers everywhere.

MARINE ELECTRIC SETS.—The C & C Electric Co., 143 Liberty street, New York, has of late entered extensively into the production of generating sets, especially designed for steamship lighting, in which ironclad water-proof dynamos are used in direct connection with either a Case or a Forbes vertical engine. The company now has orders on file for quite a number of these combinations, prominent among them being two 15 K. W. sets for the United States Government, and sets ranging in capacity from 3 to 10 K. W. for the Boston Patrol Boat Co., Harlan & Hollingsworth Co., Wilmington, Del.; Weise Bros., Davenport, Ia., and others.

BEACON INCANDESCENT LAMPS.—For a number of years it has been the endeavor of lamp manufacturers to construct an incandescent lamp which will retain its initial candle power for the largest possible number of hours. It appears from numerous tests that the Beacon Lamp Co., of New Brunswick, N. J., has succeeded in producing a lamp that is claimed to retain its initial candle power for over 300 hours. The company is prepared to send lamps to any one desirous of making their own tests, free of expense, so that they may judge for themselves how the Beacon lamp compares with others. The standard efficiency guaranteed by the company is 3.5 watts per candle, but lamps are made from 2.75 watts upward.

Graphite Lubrication

There is no substance known so smooth or so enduring as **Dixon's Pure Flake Graphite.** It is the best solid natural lubricant ever discovered. It is not affected by heat or cold, acids or alkalies. It is absolutely indispensable to every marine, stationary or locomotive engineer.

Largely increases the lubricating value of all oils or greases.

Will cool bearings and stop "groaning" or squeaking when all other lubricants fail.

It will pay you to send for Sample and Pamphlet. No charge.

JOSEPH DIXON CRUCIBLE CO., Jersey City, N.J.

AN OPPORTUNITY FOR MARINE ENGINEERS

AMERICAN SCHOOL OF CORRESPONDENCE

(Chartered by the Commonwealth of Massachusetts)

Offers a Thorough Course in

MARINE ENGINEERING.

We make a SPECIALTY of teaching Steam, Electrical and Mechanical Engineering.

Our COURSES are thorough and practical.

Our ADVISORY BOARD consists of experts of world-wide fame.

Our INSTRUCTORS are graduates of the best technical schools.

Our TERMS are low and within reach of every wage-earner.

Hundreds of ambitious ENGINEERS, ELECTRICIANS and MECHANICS have secured better positions and larger salaries through the up-to-date technical education received from our school. We have helped others and we can help YOU.

Special Offer to Readers of "Marine Engineering."

33 1/3% REDUCTION. For another 30 days we will **FOR 30 DAYS.**

continue to offer **33 1/3% REDUCTION** from our regular tuition fee to all readers of MARINE ENGINEERING. Write for our new handbook "N" containing schedules of courses, names of instructors, pages from instruction papers, etc.

AMERICAN SCHOOL OF CORRESPONDENCE,

BOSTON, MASS.

MARINE GLUE.—L. W. Ferdinand & Co., 184 Federal street, Boston, Mass., are sending out a circular regarding the genuine Jeffery's marine glue, of which they are sole American importers and agents.

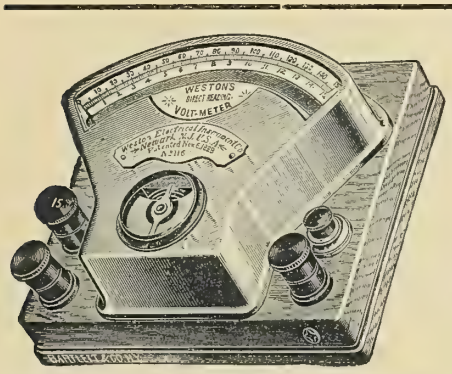
HOWDEN HOT DRAFT.—Two winters ago the Dry Dock Engine Works, Detroit, Mich., refitted the wooden steamer R. P. Ranney and installed the Howden draft apparatus. Some months later a letter was received from Chief Engineer James D. Stuart, saying: "We make a trip on 150 tons of $1.75 slack and always have all the steam we want. The Howden system has made a difference of from 35 to 50 tons of fuel on a trip and a difference of 35 cents a ton cost in favor of your boiler. * * * * * * I have no trouble at all chasing firemen; can take any kind of a man and he can make all the steam I want and in all conditions and with any kind of fuel." Pamphlets regarding the Howden system can be had by application to the Dry Dock company.

AN ACETYLENE SEARCH-LAMP.—Yachtsmen and owners of other craft will be interested in a powerful and inexpensive search light using acetylene gas, thus doing away with the necessity for fitting up with electrical apparatus. The light is made by J. B. Colt & Co., 3 to 7 West 29th street, New York, and is 14 in. dia., with a double reflector, which saves loss of light. It has both horizontal and vertical motion, and can be held rigidly in any position. It will make objects visible within a radius of hundreds of feet, and a newspaper, it is said, can be read over a thousand feet away. For any form of work at night this light is valuable. It can be mounted on any kind of a stand for contractors, lighting docks, vessels, etc. One generator only is required for several lights if near together, or for a number of lights for ordinary illuminating purposes in cabins, etc. The United States Government now uses this light in connection with range finders and for signal service.

WILLIAMS SUBMARINE COMPOUND.—After seven years' repeated use, the Red D Line SS. "Philadelphia" was taken to the Cramps' yard to be lengthened. A report says: "So well had the iron been protected that it was impossible to see the rivets or the least particle of rust on the plates." All the vessels of the Red D Line are painted with Williams submarine compound, and copies of a letter regarding the use of this can be had by sending to the manufacturer, Produce Exchange, New York.

ASBESTOS FIRE BOARD.—Professor Norton recently made a test of Asbestos Air Cell Fire Board to test its efficiency for protecting wooden surfaces, under the auspices of the Manufacturers' Mutual Fire Insurance Co. The report states that this fire board is not only remarkable as a non-conductor, but its durability and strength make it of much value for covering wooden surfaces. It is indestructible by fire and does not deteriorate with age. This board is made by the New York Asbestos Mfg. Co., 287 Douglass street, Brooklyn, N. Y.

RUBBERBESTOS GASKETS.—A. W. Chesterton & Co., 49 India street, Boston, Mass., are putting on the market a new line of gaskets made of rubberbestos. It is a new and improved sectional gasket, and the cut in the advertisement in this issue shows the form of coupling used. The gasket is similar to the hollow ones already on the market, the principal improvement being in the wire mesh, which is braided and incorporated on the inside, adding to the pressure resisting qualities. The material of which the gasket is made is the new compound rubberbestos. The ends of the coupling are larger in diameter than the center, and from its shape cannot easily be withdrawn after being once placed in position. The pressure on the plate pressing on the part of the gasket inside the head of the coupling forces it down on the coupling, thus making it impossible to blow out.



Weston Standard Portable Direct Reading Voltmeter.

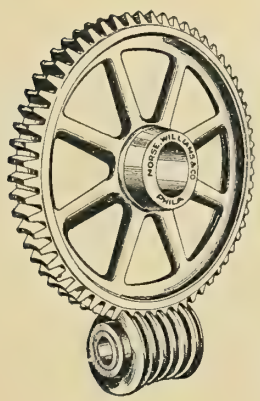
WESTON STANDARD PORTABLE

DIRECT READING

VOLTMETERS, AMMETERS, MILLIVOLTMETERS, VOLTAMMETERS, MILLIAMMETERS, OHMMETERS, PORTABLE GALVANOMETERS, GROUND DETECTORS AND CIRCUIT TESTERS.

Our Portable Intruments are recognized as **THE STANDARD** the world over. Our **VOLTMETERS** and **AMMETERS** are unsurpassed in point of extreme accuracy and lowest consumption of energy.

WESTON ELECTRICAL INSTRUMENT CO.,
114-120 William St., NEWARK, N. J., U. S. A.



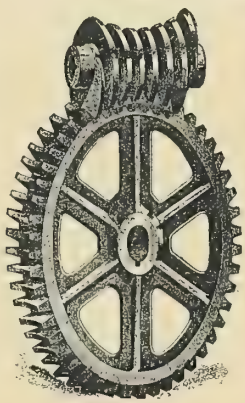
HINDLEY WORM GEARING

Is in general use in the machinery of modern vessels. Write for our descriptive circular, showing how this styte gearing gives THE BEST RESULTS.

MANUFACTURED BY

MORSE, WILLIAMS & CO.,
PHILADELPHIA, PA.

HINDLEY AND ALBRO



Worm Gearing

Consumes less power and gives better results than the old style worm gearing.

Albro-Clem Elevator Co.,
Philadelphia, Pa.,
U. S. A.

PROPELLER WHEELS.—The Sheriffs Mfg. Co., Milwaukee, Wis., recently shipped a 9 ft. propeller wheel to Montreal, Canada, and is reported to have received an order for a somewhat smaller wheel, to be shipped abroad through New York.

STEAM MOTOR.—The steam motor illustrated and mentioned in our advertising columns by James T. Halsey, Twenty-sixth and Callowhill Sts., Philadelphia, is especially designed for operating ventilating fans and for propelling boats. It needs no attention, and can be placed in any position. Full particulars regarding it can be had by applying to Mr. Halsey.

BRASS AND COPPER TUBING.—Users of seamless drawn brass and copper tubing; also other brass and copper goods, yellow metal, babbit and anti-friction metals would do well to send to Merchant & Co., 517 Arch street, Philadelphia, Pa., for catalogues and other information. This company makes a specialty of this line of goods, and has branch offices in various parts of the country.

CORRESPONDENCE INSTRUCTION.—Rapid strides have been made of late years in the matter of instruction by correspondence, and eminent among the institutions teaching in this manner are the International Correspondence Schools, P. O. Box 1111, Scranton, Pa. The school was established in 1891, and now has special departments in all branches of engineering, being especially strong in all branches of marine work. Full information concerning the various courses can be had upon application.

THE PARAGON BOILER.—The Paragon boiler has been given a practical test on the canal steamer Arthur D. Bissell. This steamer, carrying 135 gross tons, has towed five heavily loaded consorts from New York to Buffalo. The combined tonnage of the freight was 915 tons, and the boats averaged 60 tons, making the total weight of boats and cargoes 1,275 tons. With this tow the steamer burned only 1½ tons of coal per 24 hours, so we are informed by Captain M. De Puy, 19 South street, New York. The captain is now building a steamer named the "Paragon," which is just being put into commission.

ELECTRICAL MACHINERY.—A complete line of electrical machinery for all uses is made by the Westinghouse Electrical & Mfg. Co., Pittsburg, Pa. For use on steam vessels this company offers an electric set comprising a Westinghouse dynamo direct connected to a Westinghouse engine, making one of the most complete sets built. In regard to electric motors, an exceptionally handsome catalogue has just been published, entitled "Electricity for Machine Driving," which will be sent to all readers of Marine Engineering writing for them. Another catalogue of unusual interest is entitled "Quarter of a Million Horse Power." There is much information in both catalogues regarding the great electric power plant at Niagara Falls. Copies of these catalogues can be had upon application to the company.

ICE MACHINES FOR THE NAVY.—The steamships Pennsylvania and Illinois, recently sold by the International Navigation Co. to the government are equipped with refrigerating plants made by the Kilbourn Construction Co. It is only necessary to run one of these plants seven hours per day, a small 5 by 10 in. Compressor doing the work. A cold storage machine of the type mentioned has the following dimensions: Compressor—Cylinder, 5 in. dia. by 10 in. stroke; at 60 rev. (minimum) displaces 23,556 cu. in. of gas; 3.36 tons refrigeration; 954,240 B. T. U.; 9,542 cu. ft. refrigeration. At 120 rev. (maximum) 47,112 cu. in. displacement; 6.73 tons refrigeration; 1911.320 B. T. U.; 19,113 cu. ft. refrigeration. Engine—Horse power required to drive compressor, at 60 rev., 3.57; at 120 rev., 7.14. This plant occupies but 10 ft. square, grouped.

GOVERNMENT SPECIFICATIONS.

The United States Government, especially the Navy Department, is a believer in paint, both as a preservative and for its beautifying qualities. Having at its command the services of the most experienced experts, it indulges in no theories and tolerates no sentiment in the selection of materials; but patiently determines what is best for a given purpose, and then orders the use of exactly that material.

To paint users in general the specifications and practice of the Government are, therefore, interesting and enlightening. Of special importance is the fact that wherever paint is to be exposed to the action of salt water or sea air, zinc white is an essential ingredient. An official at one of the largest navy yards being asked recently by a large bidder for supplies, "What do you do with all the zinc white shipped you?" answered, "We use it in everything; even in red lead."

Similar testimony is offered in the specifications for the U. S. Lighthouse Establishment, which read as follows:

White Paint:

"American white lead and American white zinc dry in proportions of ¼ of the former to ¾ of the latter.

"*White* turpentine liquid drier.

"*Refined* linseed oil."

Cream-Color and Straw-Color Paints:

"Base to best American white zinc.

"English yellow ocher.

"Turpentine liquid drier.

"Refined linseed oil.

"The colored paints are wanted for outside use, and are required to withstand the bleaching effects of salt water and sunlight."

Zinc White is the one white paint material which is capable of resisting salt water and salt air; there is no other pigment fit for use under all conditions of marine service. Added to other materials it gives them durability.

THE NEW JERSEY ZINC COMPANY.

REDUCING VALVES

to control or reduce steam, water or air pressures.

"MASON"

Valves have had a world-wide reputation for years.

Write for prices.

THE MASON REGULATOR CO.,

BOSTON, MASS.

PATENTS SECURED.

Inventors desiring to secure full information in regard to the necessary course to pursue to obtain a patent, should send for our booklet on the subject.

MAILED FREE TO ANY ADDRESS.

PATENT DEPARTMENT:

THE POWER PUBLISHING CO.,

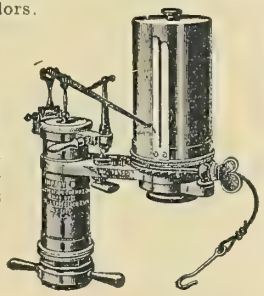
WORLD BUILDING, NEW YORK.

SEND 2 LABELS

cut from front of boxes of EUREKA PACKING and we will send you a pack of beautiful playing cards. All being special in 3 colors.

MARINE ENGINEERS

should own an INDICATOR and know how to use it. Send for circular and *special* prices. It will interest you.



Jas. L. Robertson & Son,
218 Fulton St., N. Y.

H. B. ROELKER,

CONSULTING AND CONSTRUCTING ENGINEER.
Manufacturer of **Screw Propellers** for Usual and for Special Work.
The Allen Dense Air Ice Machine for Steam Vessels.
41 MAIDEN LANE, NEW YORK.

THE NEW HAVEN LINE.

The famous boats Richard Peck and C H. Northam afford the only service by water between New York and New Haven, reaching New Haven in plenty of time in the morning to make connections by rail for any part of New England.
E. F. DEYOUNG, Treasurer and Agent,
Piers 25 and 26, East River, New York.

LINENOID GOODS.—A small launch which is seamless and made of linenoid is being put on the market by Crane Bros., Westfield, Mass. A small gasolene engine furnishes the motive power, and for such uses as yacht tenders, etc., it is proving very popular.

BOILER GASKETS.—The boilers of the New Haven steamer Richard Peck are fitted with Excelsior boiler gaskets, manufactured by the Boston Belting Co., Boston, Mass. Chief Engineer Macdonald, of the steamer, in writing to the manufacturer, says: "We have had them in use four years and have compared them with about every other kind of gasket, and have found them, when used in connection with steam at 160 lbs., to give better results and be more durable and economical than any gaskets we have used."

STOREY MOTORS.—Owing to the great increase in business the Storey Motor & Tool Co. has removed from Philadelphia to 464 So. Broad St., Trenton, N. J., with the Trenton Iron Co. The new quarters give largely increased facilities for the manufacturers of the Storey multipolar enclosed dust-and-moisture-proof motors, which have already established their reputation. These motors are light in weight, and can be arranged for slow speed and adapted for almost any class of work. Information can be had by applying to the company.

Extra Heavy Gate Valves

FOR HIGH PRESSURE STEAM.

Balanced Expansion Joints and Flanged Fittings.
Send for Catalogue.
COLDWELL-WILCOX CO., Newburgh, N.Y.

Electricity for Marine Engineers

Every intelligent engineer appreciates the fact that a working knowledge of electrical engineering has now become one of the conditions upon which many of the best positions depend.

Our Junior Course in Electrical Engineering

meets this want. For our handsome illustrated FREE book entitled **"Can I Become An Electrical Engineer?"** address

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HERMAN A. STRAUSS, E. E., General Manager